Abt Associates Inc.
4800 Montgomery Lane
Bethesda, MD 20814
www.abtassociates.com

# Modeled Attainment Test Software

## User's Manual

May 2007

Prepared for
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC
Brian Timin, Project Manager

Prepared by
Abt Associates Inc.

# Table of Contents

# 1 Welcome to MATS, the Modeled Attainment Test Software

The Modeled Attainment Test Software (MATS) is primarily intended as a tool to implement the modeled attainment tests for particulate matter ($PM_{2.5}$) and ozone ($O_3$), and to perform the uniform rate of progress analysis for regional haze (visibility). Detailed information on the attainment tests can be found in U.S. EPA's modeling guidance, "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of the Air Quality Goals for Ozone, $PM_{2.5}$ , and Regional Haze." The modeling guidance can be found at http://www.epa.gov/ttn/scram/guidance_sip.htm.

This Chapter provides a brief description of how to use this manual, computer requirements, steps to install and uninstall MATS, and contact information for comments and questions:

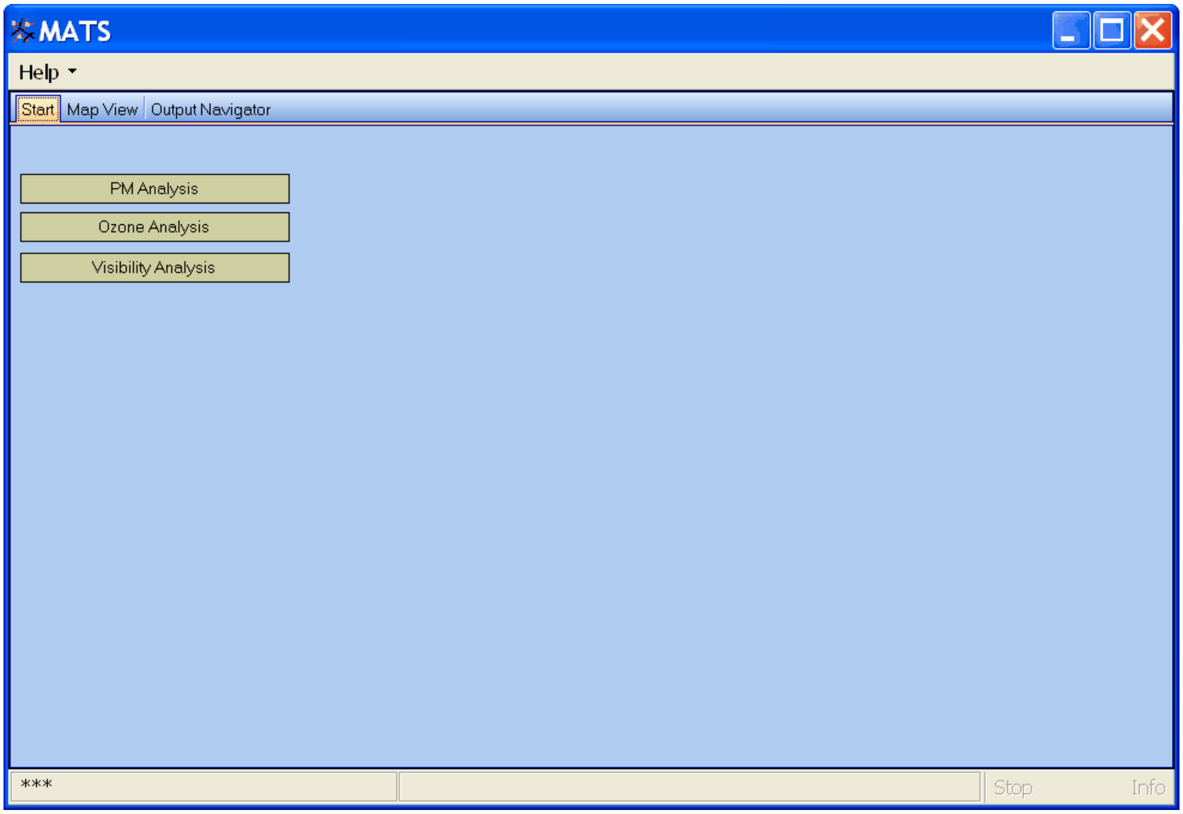
How to Use this Manual

Computer Requirements

Installing MATS

Uninstalling MATS

Contact for Comments and Questions.




## 1.1 How to Use this Manual

This manual provides step-by-step instructions on how to use MATS.

New users should start with the Overview of MATS Components chapter, which is very short, but provides a good overview of the model and how it works. You can then use tutorial chapters to get started using the model. There are separate tutorials for Particulate Matter (PM), Ozone, and Visibility. In addition to these relatively simple tutorials, you can go on to learn more on each subject in the chapters on PM Analysis: Details, Ozone Analysis: Details, and Visibility Analysis: Details. Use the rest of the manual to answer any specific questions you may have. There is a chapter on the Output Navigator, which is the starting point for examining your results. The Map View chapter details how to map results. Finally, the Frequently Asked Questions chapter reviews and answers some of the common questions that arise when using MATS.

In sections that provide instructions on navigating the model, the following conventions are observed: menu items, buttons, and tab and selection box labels are in bold type; prompts and messages are enclosed in quotation marks; and drop-down menu items, options to click or check, and items that need to be filled in or selected by the user are italicized. Common terms are defined in the Terminology and File Types chapter. The Reference section provides citations for documents relevant to MATS.

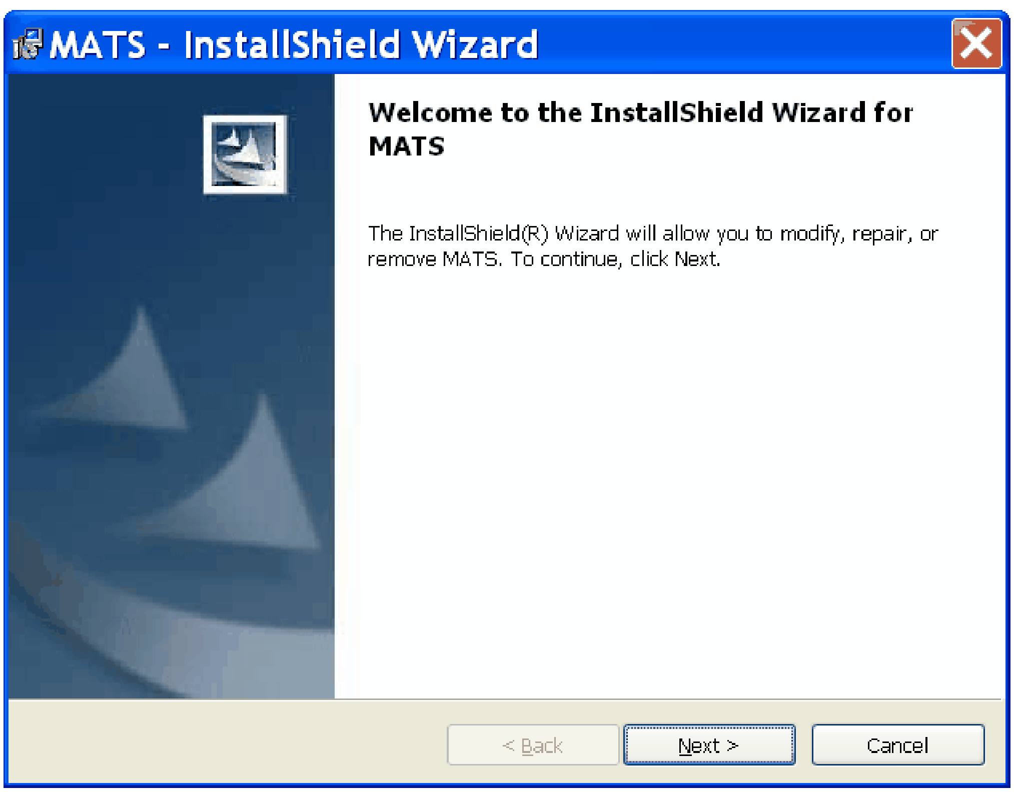
## 1.2 Computer Requirements

MATS requires a Windows platform, and can be used on machines running Windows2000, as well as more recent versions of Windows. In particular, MATS requires a computer with:

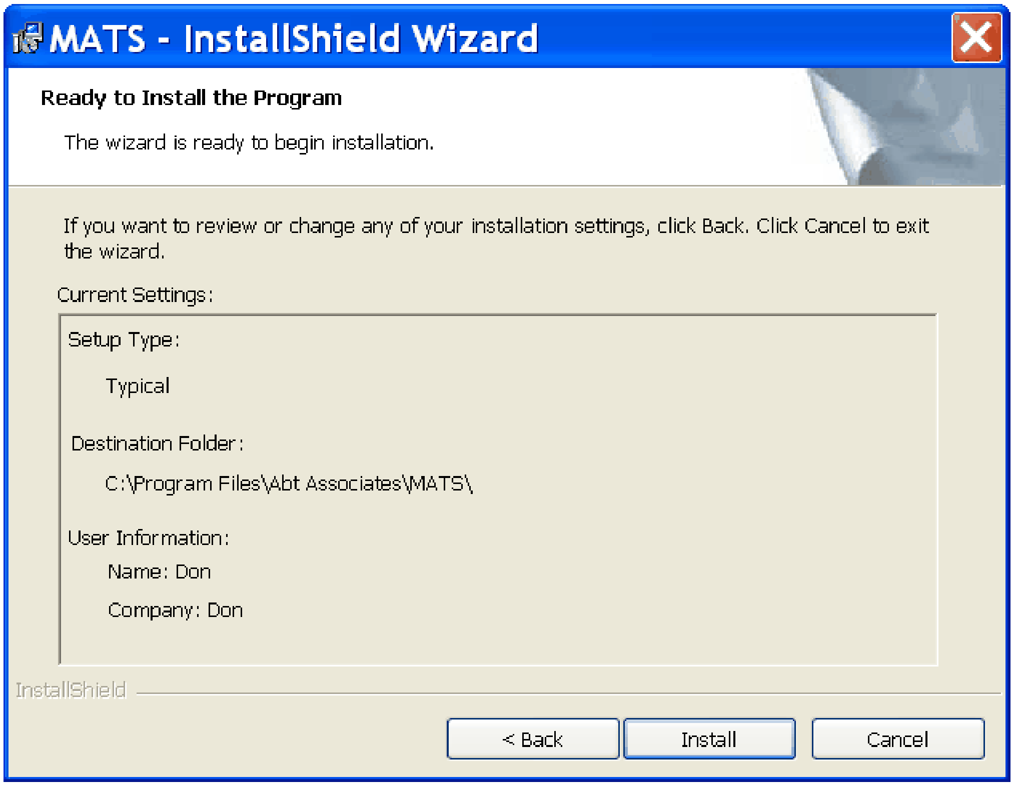
- Windows 2000 or greater.
- 512 megabytes of RAM or greater.
- Intel® or compatible processor, Pentium 166 MHz or higher. 1 GHz processor or greater recommended for optimum performance.
- A CD-ROM drive for CD based installation. Alternatively, a high speed internet connection can be used to download the installer. The installer package can be found at:
- At least 3 GB free space recommended.

## 1.3 Installing MATS

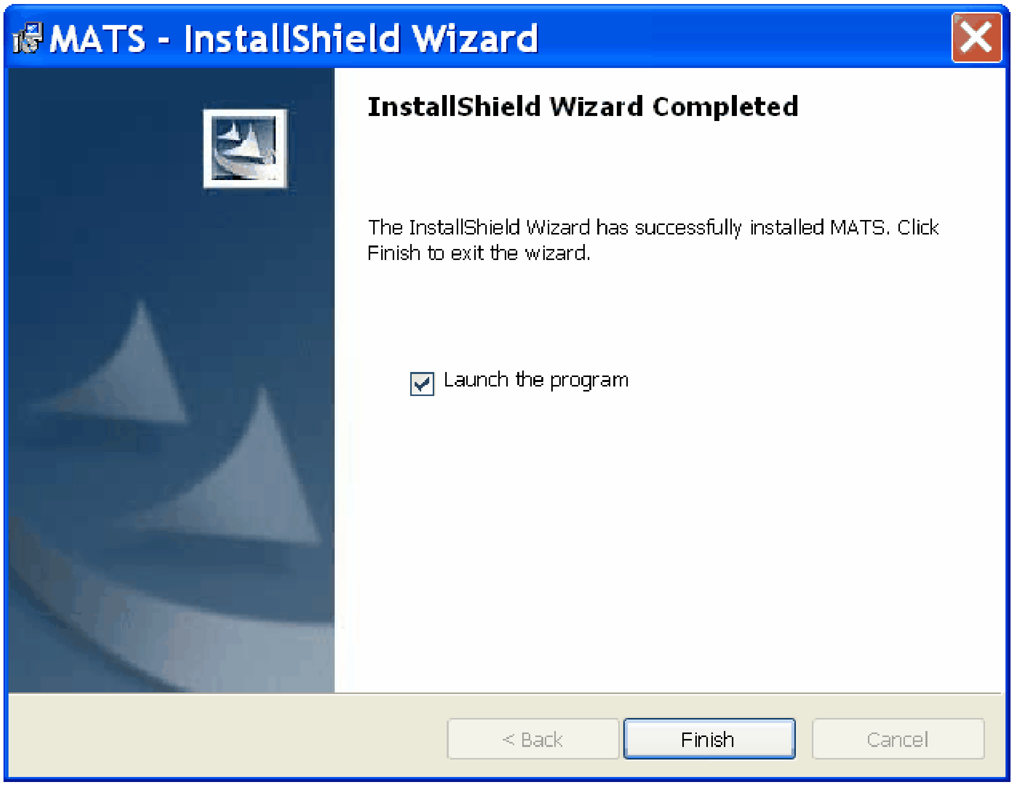
Load the installation file (MATS_Setup.exe) onto your hard drive. Double-click the file. This will initiate the installation process, which takes about five to ten minutes, depending on the speed of your computer.



Click the **Next** button.  This will bring up the **MATS - InstallShield Wizard**.




Click the **Install** button.  After the installation of MATS, a final window will appear to complete the process.




Click the **Finish** button.

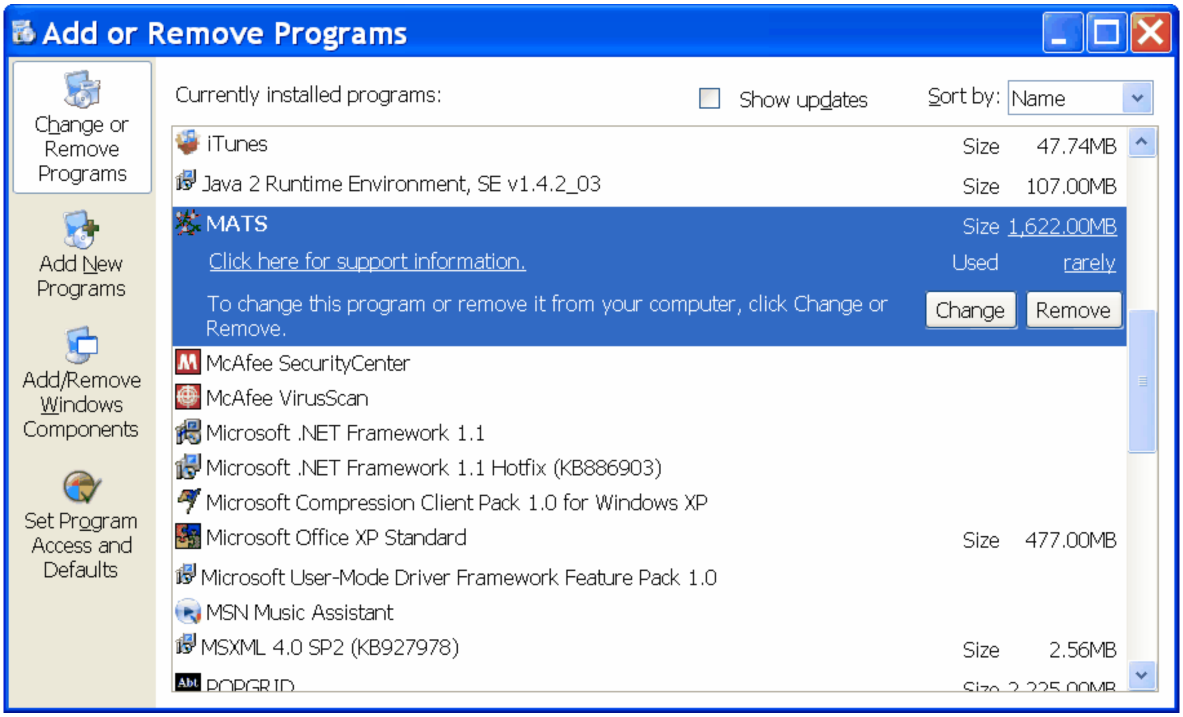
Note that some problems have occurred in the past, when trying to install MATS from a network drive. If this problem occurs, move the MATS_Setup.exe file to your local hard drive.

## 1.4 Installing an Updated Version of MATS

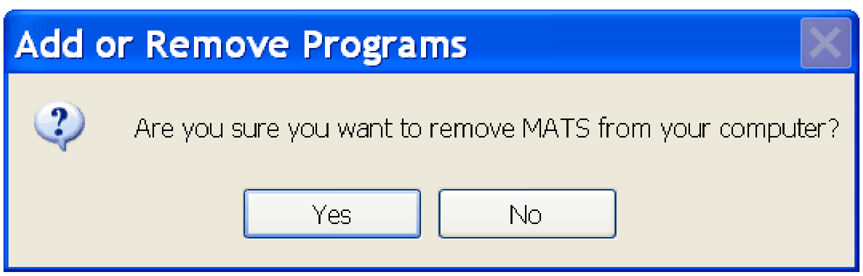
If a previous version of MATS is already installed on your computer, you will need to uninstall the old version using the Windows Control Panel prior to installing the new version (see next section). Note that uninstalling MATS will <u>not</u> delete your MATS output files.

## 1.5 Uninstalling MATS

To uninstall MATS, go to Control Panel, Add/Remove Programs and highlight MATS.




Click the Remove button. This will bring up a window asking you to confirm the removal.




Note that removing the software will not remove the files that you have generated with MATS. For example, the Output folder will remain with any files (*e.g.*, *.ASR files) that you have created.

## 1.6 Contact for Comments and Questions

For comments and questions, please contact Brian Timin at the United States Environmental Protection Agency.

Address: C339-01, USEPA Mailroom, Research Triangle Park, NC 27711

Email: timin.brian@epa.gov

Telephone: 919-541-1850.

# 2 Terminology & File Types

The first section of this chapter explains Common Terms used in this user's manual and in the model, and references, where possible, other sections in this manual to find more detailed information. The second section describes the File Types used in MATS.

## 2.1 Common Terms

The following include terms commonly used in MATS:

ASR File

BMP File

Class I Area

Configuration File

CSV File

Deciviews

Design Value

Domain

FRM Monitors

Gradient Adjustment

IMPROVE Monitors

Interpolation

Inverse Distance Weights

Log File

Output Navigator

Output File

Point Estimate

RRF

SANDWICH

Scenario Name

SMAT

Spatial Field

Spatial Gradient

STN Monitors

Temporal Adjustment

VNA

### 2.1.1 ASR File

An ASR File contains three types of results from a MATS run: Log File, Configuration File , and Output Files. The extension .ASR is used after the Scenario Name. The data in an . ASR file can viewed and extracted using the Output Navigator.

### 2.1.2 BMP File

BMP is a standard file format for computers running the Windows operating system. The format was developed by Microsoft for sotoring bitmap files in a device-independent bitmap (DIB) format that will allow Windows to display the bitmap on any type of display device. The term "device independent" means that the bitmap specifies pixel color in a form independent of the method used by a display to represent color.*

* *See*: http://www.prepressure.com/formats/bmp/fileformat.htm.

### 2.1.3 Class I Area

A Class I Area is defined by the Clean Air Act to include national parks greater than 6,000 acres, wilderness areas and national memorial parks greater than 5,000 acres, and international parks that existed as of August 1977.* The Regional Haze rule requires visibility improvements in 156 specific Class I areas. The MATS visibility analysis will calculate visibility values for these areas.

* *See*: http://vista.cira.colostate.edu/views/Web/General/Glossary.aspx.

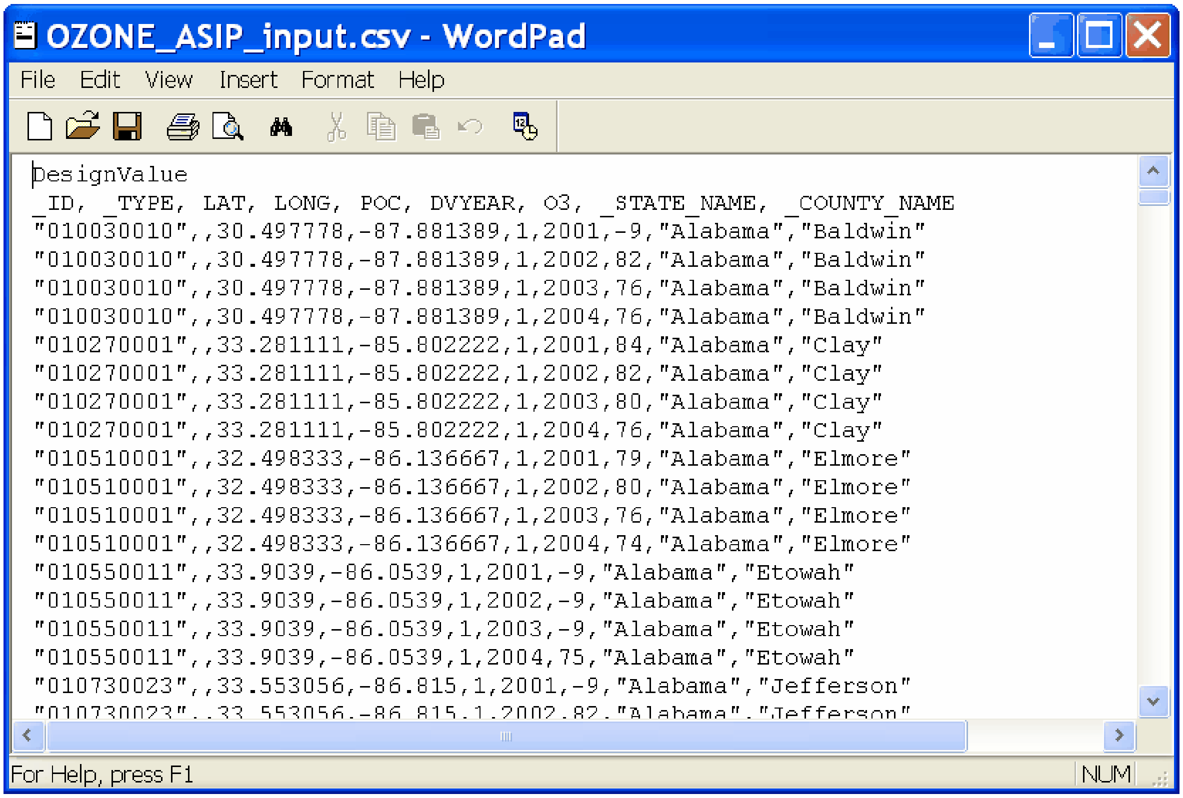
### 2.1.4 Configuration File

A Configuration File stores the choices that you have made when using MATS. A useful feature of a Configuration File is that it is reusable. You can use an existing Configuration File, make some minor changes to generate a new set of results, without having to explicitly set each of the choices you made in the previous Configuration. The section on the Output Navigator provides additional details on accessing and viewing a Configuration File.

### 2.1.5 CSV File

Is a comma separated values (CSV) file (*.csv) which can be read using a text editor, or by various spreadsheet and database programs, such as Microsoft Excel.

Note: Detailed formatting in .csv files such as leading zeroes and "" cannot be seen in Excel. To see formatting of MATS input files, open .csv files with a text editor, such as WordPad.




```
DesignValue
_ID, _TYPE, LAT, LONG, POC, DVYEAR, O3, _STATE_NAME, _COUNTY_NAME
"010030010",,30.497778,-87.881389,1,2001,-9,"Alabama","Baldwin"
"010030010",,30.497778,-87.881389,1,2002,82,"Alabama","Baldwin"
"010030010",,30.497778,-87.881389,1,2003,76,"Alabama","Baldwin"
"010030010",,30.497778,-87.881389,1,2004,76,"Alabama","Baldwin"
"010270001",,33.281111,-85.802222,1,2001,84,"Alabama","Clay"
"010270001",,33.281111,-85.802222,1,2002,82,"Alabama","Clay"
"010270001",,33.281111,-85.802222,1,2003,80,"Alabama","Clay"
"010270001",,33.281111,-85.802222,1,2004,76,"Alabama","Clay"
"010510001",,32.498333,-86.136667,1,2001,79,"Alabama","Elmore"
"010510001",,32.498333,-86.136667,1,2002,80,"Alabama","Elmore"
"010510001",,32.498333,-86.136667,1,2003,76,"Alabama","Elmore"
"010510001",,32.498333,-86.136667,1,2004,74,"Alabama","Elmore"
"010550011",,33.9039,-86.0539,1,2001,-9,"Alabama","Etowah"
"010550011",,33.9039,-86.0539,1,2002,-9,"Alabama","Etowah"
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"010550011",,33.9039,-86.0539,1,2004,75,"Alabama","Etowah"
"010730023",,33.553056,-86.815,1,2001,-9,"Alabama","Jefferson"
"010730023",,33.553056,-86.815,1,2002,82,"Alabama","Jefferson"
```

### 2.1.6 Deciviews

A third measure of visibility is the deciview index, which EPA selected as the standard metric for tracking progress in EPA's regional haze program, largely because it provides a linear scale for perceived visual changes over a wide range of conditions.1 On a particle-free, pristine day, the deciview index has a value of zero (SVR=391 km). On a relatively clear day in the Great Smoky Mountains the deciview index might be about 16 (SVR=79 km) and on a relatively hazy day the deciview index might be about 31 (SVR=201 km). For each 10 percent increase in light-extinction, the deciview index goes up by one. So, higher deciview values mean worse visibility. Under many scenic conditions, a change of one deciview is considered to be just perceptible by the average person.

### 2.1.7 Design Value

The monitored reading used by EPA to determine an area's air quality status; e.g., for ozone, the 3 year average of the annual fourth highest reading measured at each monitor is the design value. Ozone design values are calculated in accordance with 40 CFR Part

50.10, and Appendix I to Part 50. The calculation of annual and 24-hour average $PM_{2.5}$ design values can be found in 40 CFR Part 50, Appendix N.

### 2.1.8 Domain

A Domain (or Model Domain) refers to the coverage of an air quality model, or the area of the country for which there are model values. MATS calculates design values and/or spatial fields for an area encompassed by the coordinates given within a MATS input file.

### 2.1.9 Extinction

Light extinction is the sum of the light scattering and light absorption by particles and gases in the atmosphere, and is measured in inverse megameters (Mm-1), relating how much light is extinguished per megameter. Higher extinction values mean worse visibility.

### 2.1.10 FRM Monitors

Federal Reference Method (FRM) monitors used to determine attainment or nonattainment.The term "FRM" is frequently used to describe the network of $PM_{2.5}$ mass monitors.

### 2.1.11 Gradient Adjustment

A gradient adjustment is used to scale, or adjust, monitor data when using monitor data to estimate air pollution levels in unmonitored areas. It is calculated as the ratio of the model value in the unmonitored area to the value in the monitored area. In MATS, gradient adjustments can be used for PM Analyses and Ozone Analyses.

### 2.1.12 IMPROVE Monitors

Interagency Monitoring of PROtected Visual Environments (IMPROVE) is a collaborative monitoring program established in the mid-1980s. IMPROVE objectives are to provide data needed to assess the impacts of new emission sources, identify existing man-made visibility impairment, and assess progress toward the national visibility goals that define protection of the 156 Class I areas.*

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* *See*: http://vista.cira.colostate.edu/views/Web/General/Glossary.aspx.

### 2.1.13 Interpolation

Interpolation is the process of estimating the air quality level in an unmonitored area by using one or more nearby air quality monitors. The technique used in MATS is called Voronoi Neighbor Averaging (VNA).

### 2.1.14 Inverse Distance Weights

The weight given to any particular monitor is inversely proportional to its distance from the point of interest.

**Example, Inverse Distance Weights**

Assume there are four monitors (A, B, C, and D) that are a varying distance from a point E. Assume the distances are 10, 15, 15, and 20 kilometers respectively. The weights will be as follows:

$Weight_A = 10 / (10+15+15+20) = 10 / 60 = 0.17$

$Weight_B = 15 / (10+15+15+20) = 0.25$

$Weight_C = 15 / (10+15+15+20) = 0.25$

$Weight_D = 20 / (10+15+15+20) = 0.33$

**Example, Inverse Distance Squared Weights**

Assume there are four monitors (A, B, C, and D) that are a varying distance from a point E. Assume the distances are 10, 15, 15, and 20 kilometers respectively. The weights will be as follows:

$Weight_A = 10 / (10^2+15^2+15^2+20^2) = 100 / 950 = 0.11$

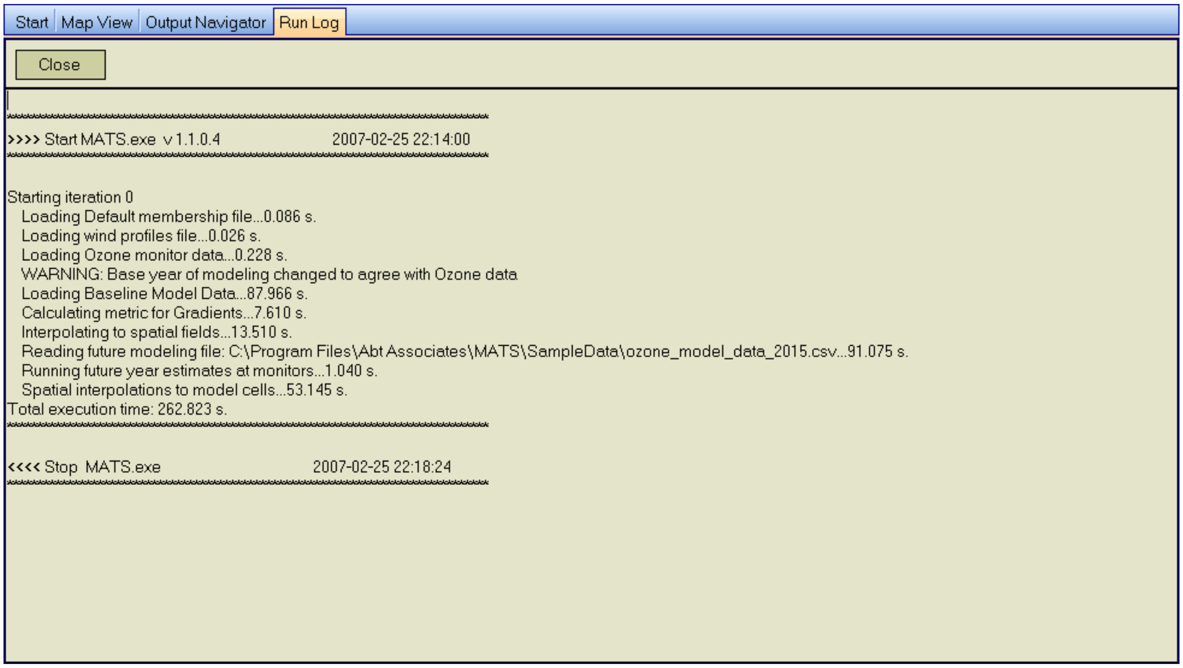
$Weight_B = 15 / (10^2+15^2+15^2+20^2) = 0.24$

$Weight_C = 15 / (10^2+15^2+15^2+20^2) = 0.24$

$Weight_D = 20 / (10^2+15^2+15^2+20^2) = 0.42$

### 2.1.15 Log File

A Log File provides information on a variety of technical aspects regarding how a results file (*.ASR) was created. This includes the version of MATS, the date and time the *.ASR file was created.




### 2.1.16 Output Navigator

The Output Navigator allows you to load results files that you have previously created. You can then view these data in maps and in tables, or export the data to text files, which you can then load into a program such as Excel. Additional details are in the Output Navigator Chapter.

### 2.1.17 Output File

An Output File is one of the file types within a *.ASR results file. The types of Output Files available depend on the type of analysis (PM, Ozone, or Visibility) and the output choices that you have specified in the Configuration File.

### 2.1.18 Point Estimate

A calculation within MATS that is performed at (or near) the location of ambient air monitors. The output files will contain base and/or future year results at each valid monitoring location.

### 2.1.19 RRF

The relative response factor is the ratio of the future year modeled concentration predicted near a monitor (averaged over multiple days) to the base year modeled concentration predicted near the monitor (averaged over the same days).

### 2.1.20 SANDWICH

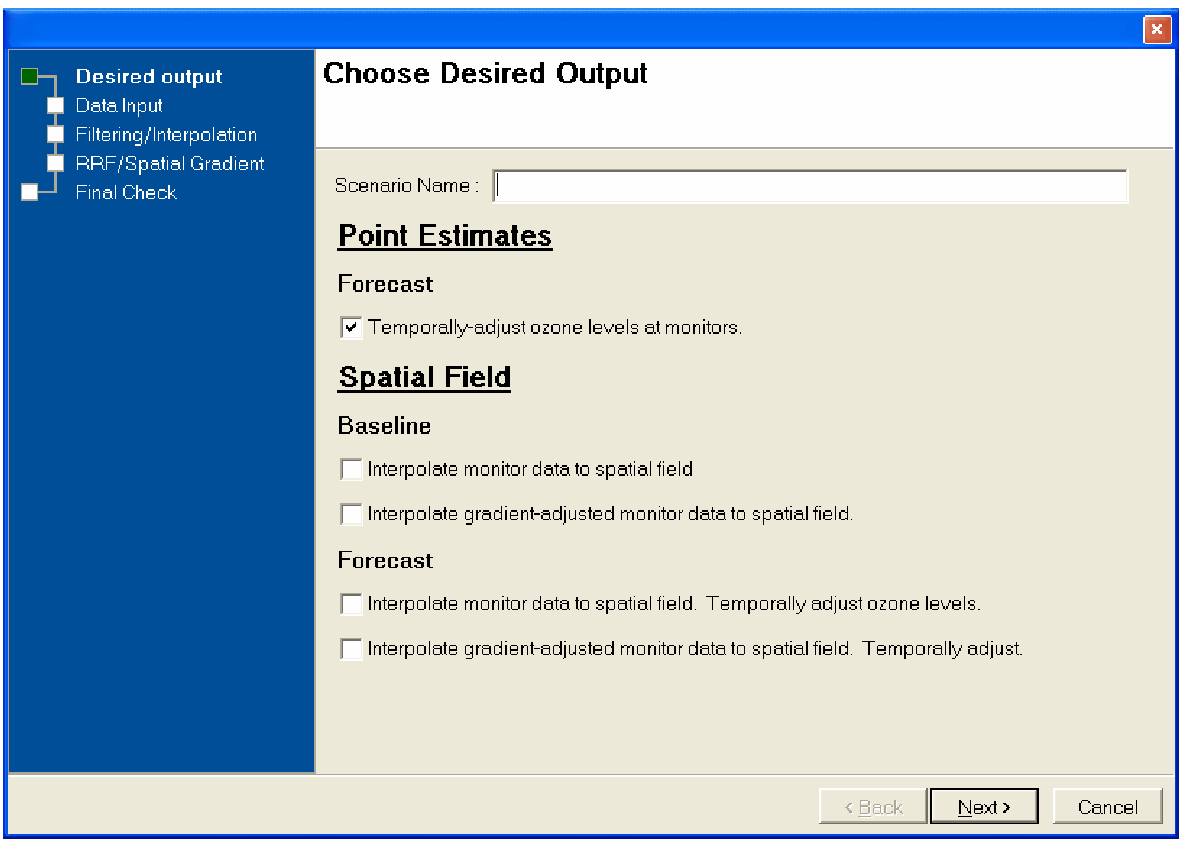
The SANDWICH process is used to adjust STN and IMPROVE monitor data so that it is consistent with FRM monitor data. SANDWICH stands for Sulfates, Adjusted Nitrates, D erived Water, Inferred Carbonaceous mass, and estimated aerosol acidity (H+).*

* For more details, *see*: Frank, N., 2006: "Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities" *J. Air Waste Mange. Assoc.*, 56, 500-511.

### 2.1.21 Scenario Name

The name given to a set of results generated by MATS. The Scenario Name is used in several ways: (1) the results file (*.ASR) uses the Scenario Name; (2) an output folder, containing results extracted from a *.ASR file, is given the Scenario Name; and (3) the Output File names begin with the Scenario Name.

The Scenario Name is specified when choosing the desired output, such as in the case of an ozone analysis.




### 2.1.22 SMAT

The Speciated Modeled Attainment Test (SMAT) is used to forecast $PM_{2.5}$ values. The main steps are as follows:

- Derive quarterly mean concentrations for each component of $PM_{2.5}$ by multiplying FRM $PM_{2.5}$ by fractional composition of each species;
- Calculate a model-derived relative response factor (RRF) for each species;
- Multiply each RRF times each ambient $PM_{2.5}$ component (for each quarter) to get the future concentrations;
- Sum the future quarterly average components; and
- Average the four mean quarterly future $PM_{2.5}$ concentrations.

### 2.1.23 Spatial Field

A Spatial Field refers to air pollution estimates made at the center of each grid cell in a specified modeling domain. For example, MATS might calculate ozone design values for each grid cell in the modeling domain. Several types of Spatial Fields can be calculated for ozone and PM. (See the sections for ozone and PM for additional details.)

### 2.1.24 Spatial Gradient

A Spatial Gradient is the ratio of mean model values at an unmonitored location over the mean model values at a monitor. Spatial Gradients can be used in the calculation of Spatial Fields for ozone and PM. (See the sections for ozone and PM for additional details.)

### 2.1.25 STN Monitors

In meeting the requirements to monitor and gather data on the chemical makeup of fine particles, EPA established a Speciation Trends Network (STN). These STN monitors were placed at various national air monitoring stations (NAMS) and State and local air monitoring stations (SLAMS) across the Nation.

### 2.1.26 Temporal Adjustment

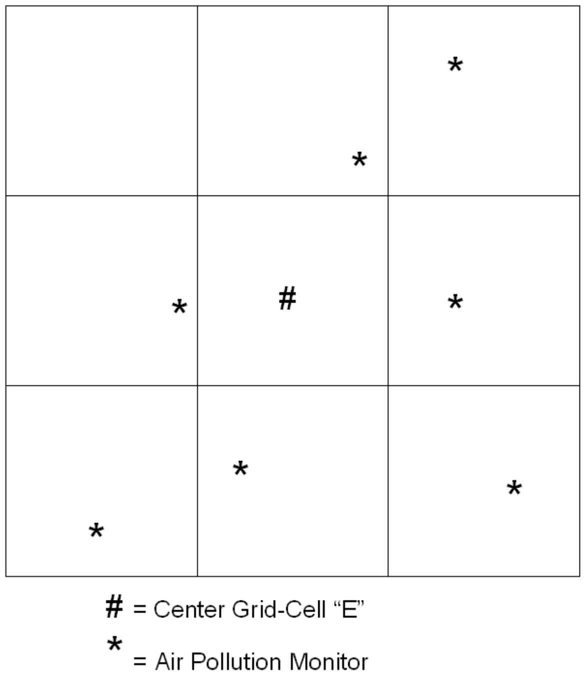
A temporal adjustment refers to multiplying ambient monitor data with a model derived relative response factor (RRF) in order to generate an estimated future year concentration.

### 2.1.27 VNA

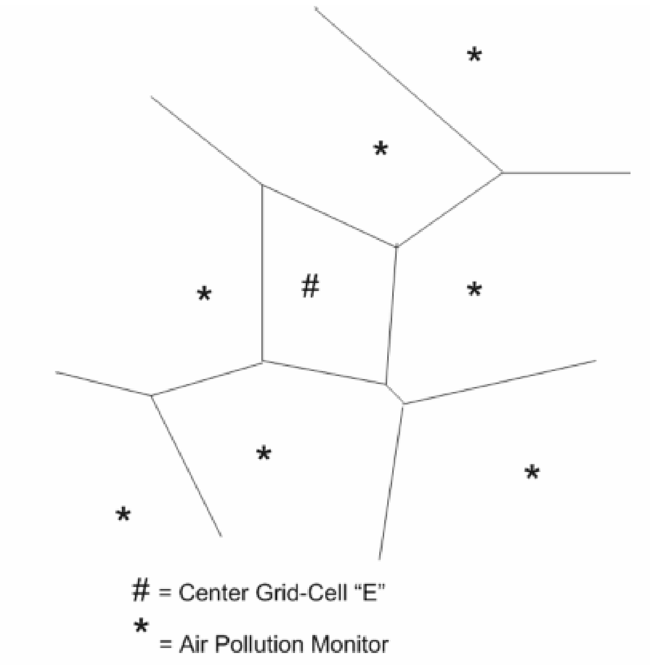
Voronoi Neighbor Averaging (VNA) is an algorithm used by MATS to interpolate air quality monitoring data to an unmonitored location. MATS first identifies the set of monitors that best “surround” the center of the population grid cell, and then takes an inverse-distance weighted average of the monitoring values.

#### 2.1.27.1 VNA - Detailed Description

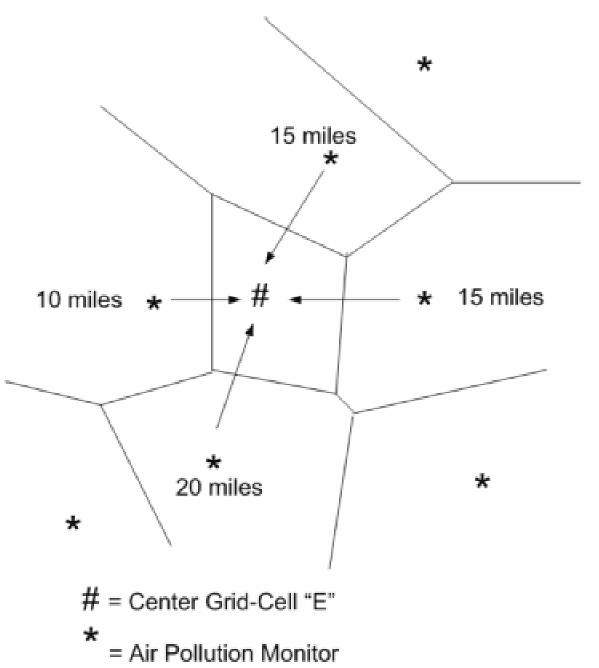
Voronoi Neighbor Averaging (VNA) algorithm uses monitor data directly or in combination with modeling data. MATS first identifies the set of monitors that best “surround” the point of interest.




In particular, MATS identifies the nearest monitors, or “neighbors,” by drawing a polygon, or “Voronoi” cell, around the center of the point of interest.  The polygons have the special property that  the boundaries are the same distance from the two closest points.




MATS chooses those monitors that share a boundary with the center of grid-cell "E." These are the nearest neighbors, we use these monitors to estimate the air pollution level for this grid-cell.

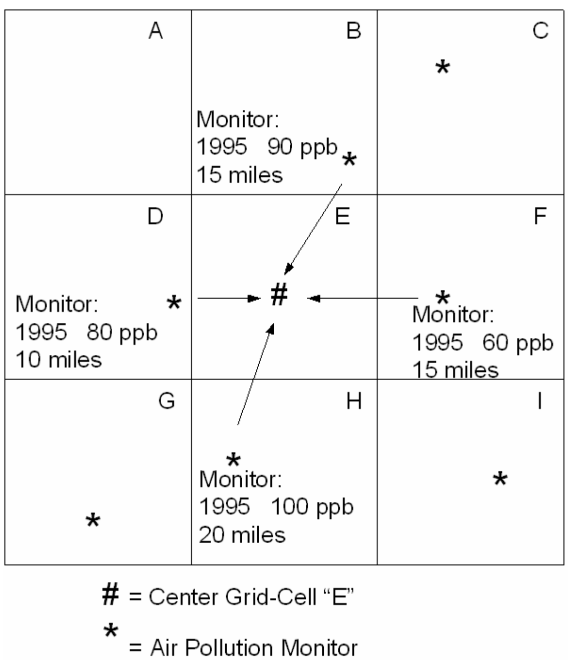



To estimate the air pollution level in each grid-cell, MATS calculates an inverse-distance weighted average of the monitor values. The further the monitor is from the grid cell, the smaller the weight. In the figure below, the weight for the monitor 10 miles from the center of grid-cell E is calculated as follows:

$$d_{i,1} = \frac{\frac{1}{20}}{\left(\frac{1}{20} + \frac{1}{16} + \frac{1}{14}\right)} = 0.27 .$$

The weights for the other monitors are calculated in a similar fashion. MATS then calculates an inverse-distance weighted average for grid-cell E as follows:

Estimate = 0.35*80 ppb + 0.24*90 ppb+ 0.24*60 ppb + 0.18*100 ppb = 81.2 ppb

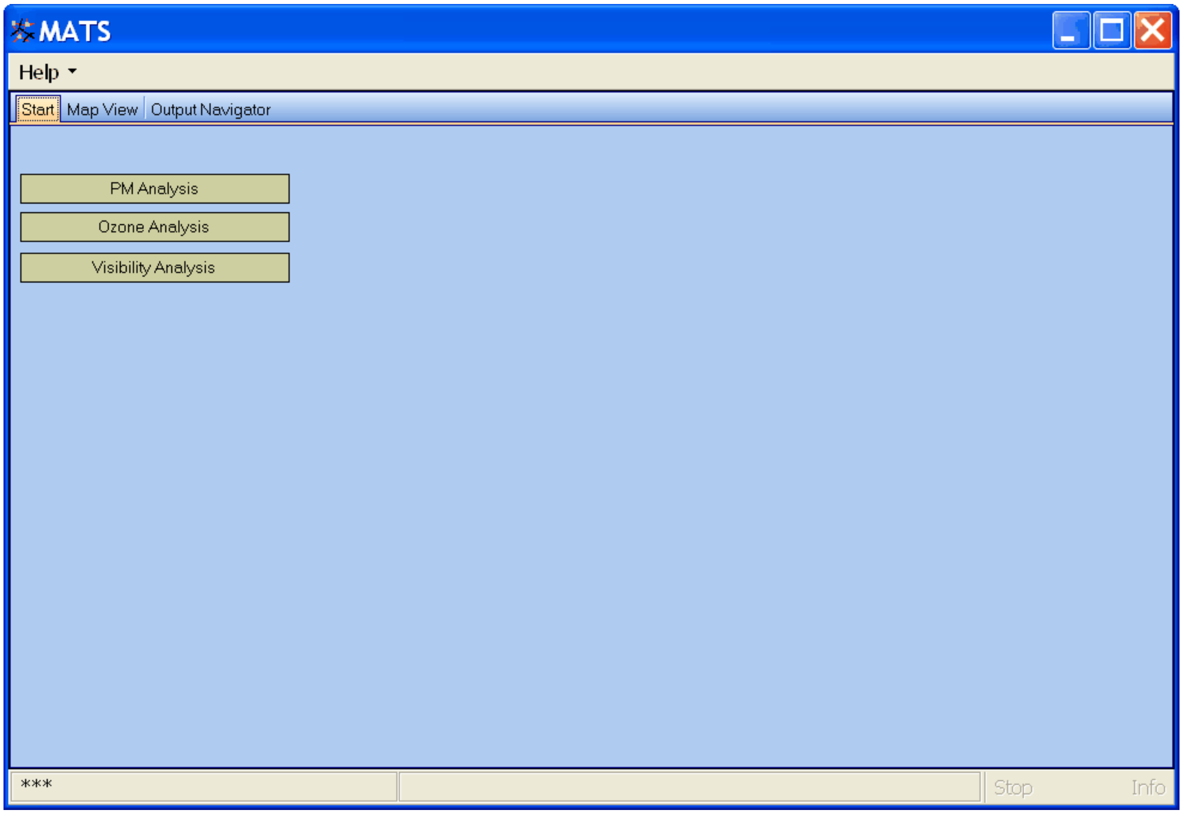



## 2.2 File Types

The primary results file generated by MATS has a .ASR extension, which is specific to MATS. To view the results you have generated in other programs (e.g., MS Excel), you can export .CSV files using the Output Navigator.

# 3 Overview of MATS Components

Upon starting MATS for the first time, you will see the following main window.

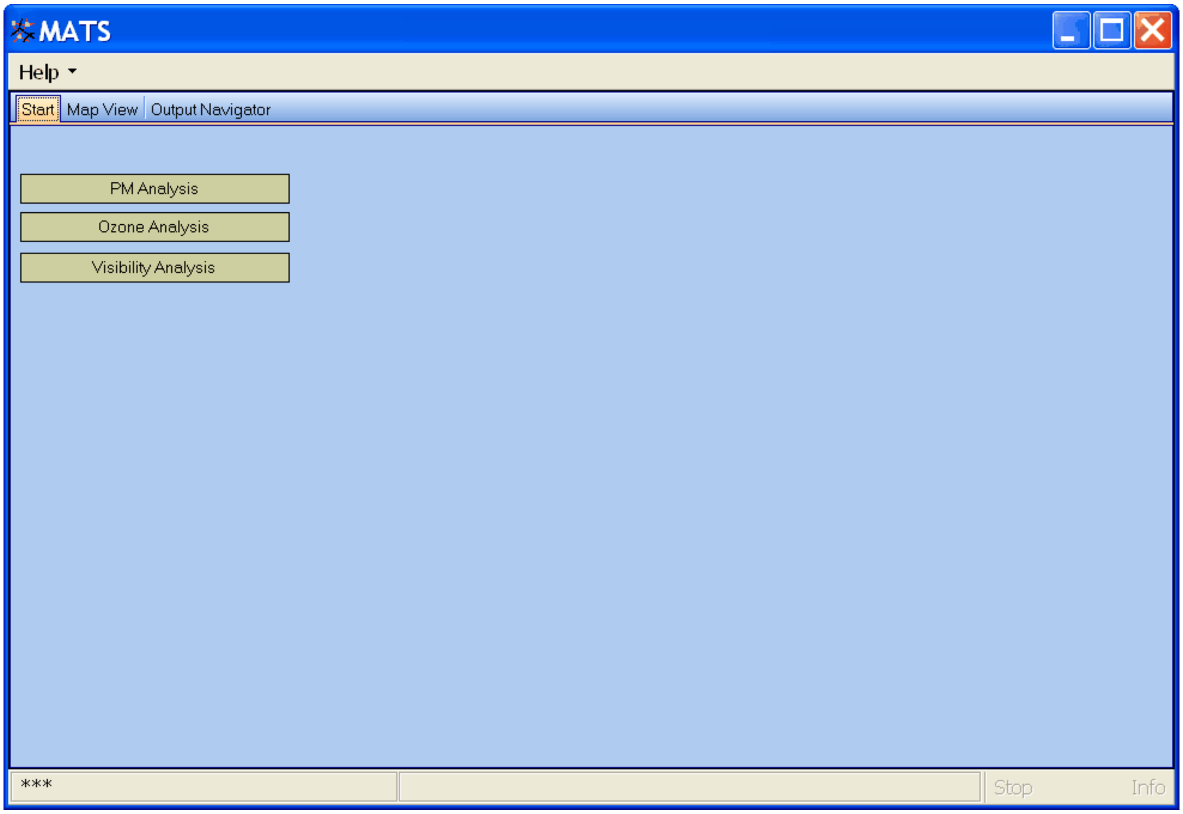



There are three main tabs: **Start**, **Map View**, and **Output Navigator**. The Start tab allows you to calculate Particulate Matter (PM), Ozone and Visibility levels. The Map View tab allows to map your results. The Output Navigator tab allows you to view your results either as tables or maps. Finally, the Help menu at the top of the main window provides explanations and examples of all of the functionality in MATS.

This Chapter gives a brief description of each of these items. All of these topics are covered in greater detail in subsequent chapters of this manual.

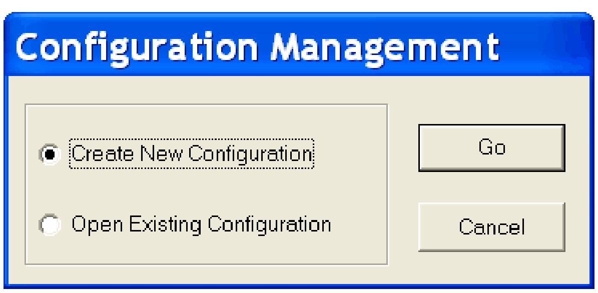
## 3.1 Start

The Start tab gives you the choice to analyze Particulate Matter (PM), Ozone or Visibility. To begin, click on one of the three buttons.




One of the key features of MATS is the Configuration. This is a reusable file that stores the choices that you have made when using MATS. You can use an existing Configuration File, make some minor changes to generate a new set of results, without having to explicitly set each of the choices you made in the previous Configuration.

When you click on one of the analysis buttons, you will be asked whether you want to create a new Configuration, or whether you want to use an existing Configuration.



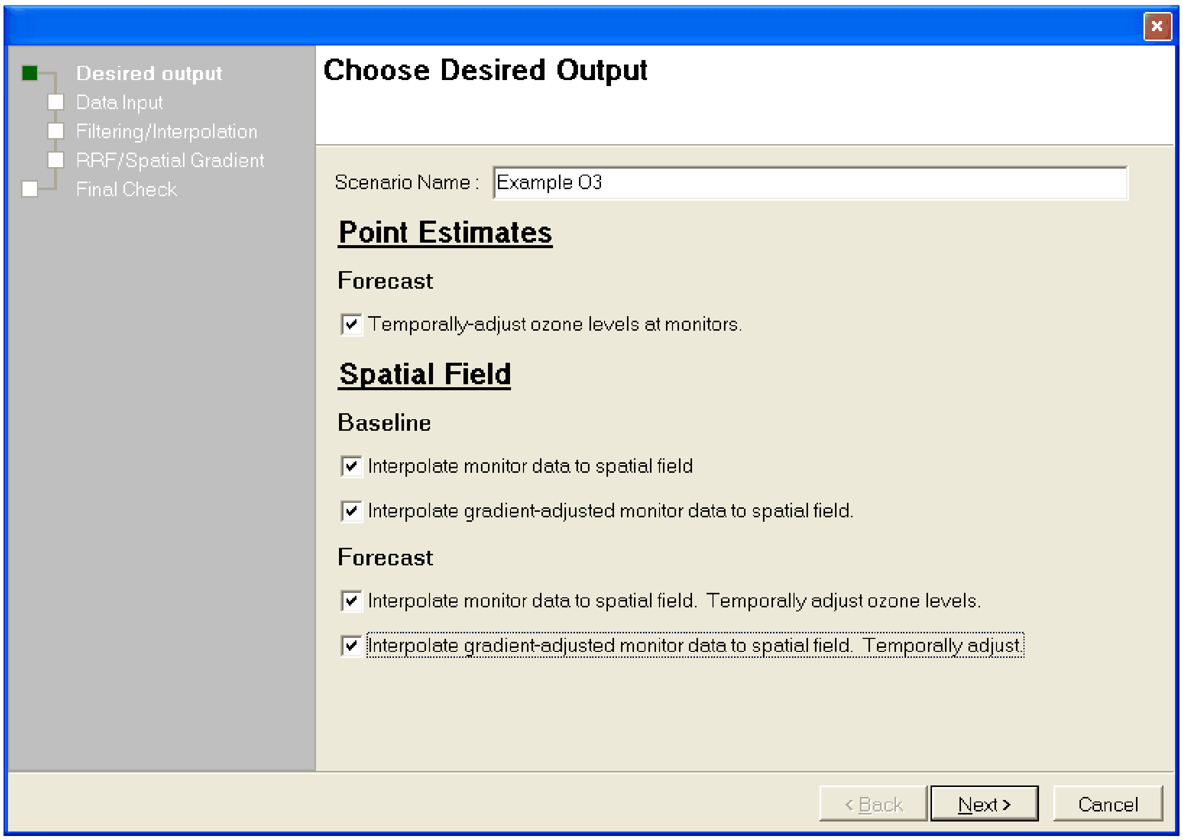

Make your choice and then click **Go**. MATS will then take you through a series of windows specifying the options available for each analysis.

### 3.1.1 PM Analysis

< To be added. >

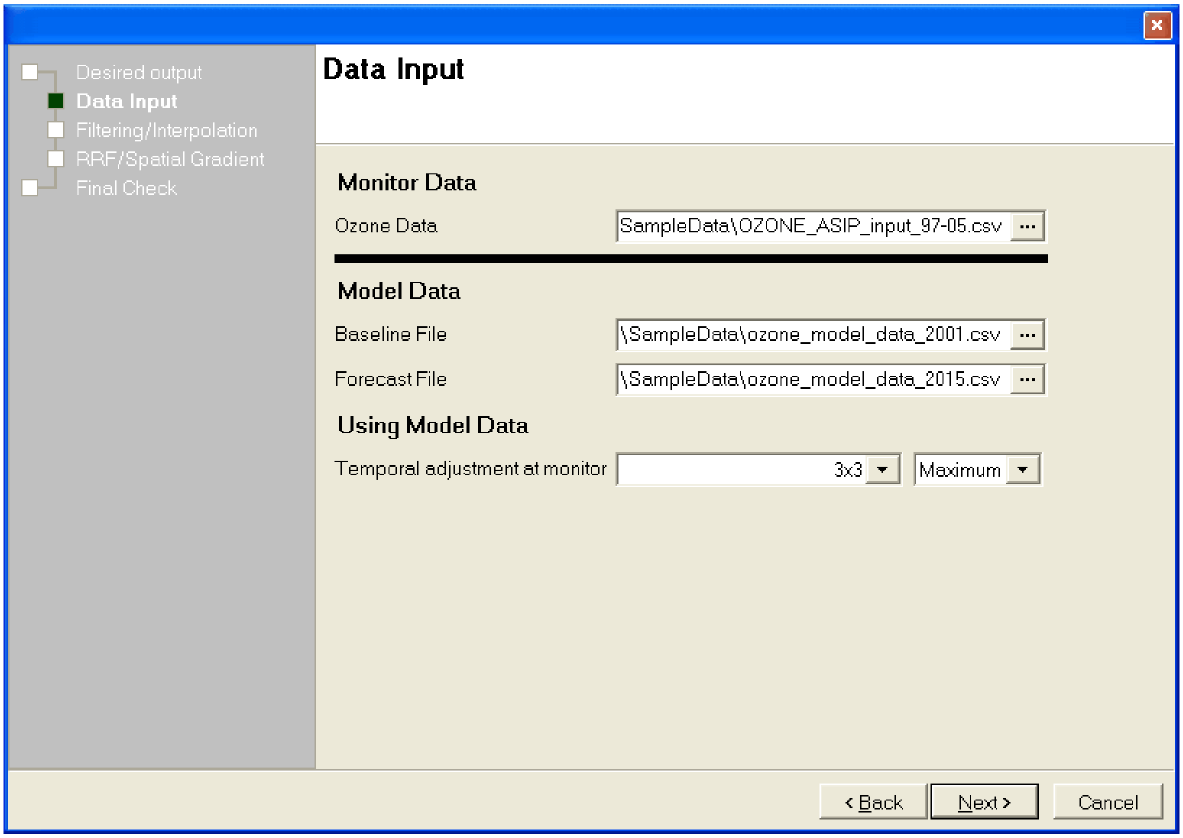
### 3.1.2 Ozone Analysis

MATS can forecast ozone design values at monitor locations -- these forecasts are referred to as Point Estimates. MATS can also use a variety of approaches to calculate design values for a Spatial Field. The **Choose Desired Output** window lets you specify the type of calculation(s) that you would like MATS to perform. These different assumptions are discussed in the Choose Desired Output section of the Ozone Analysis: Details chapter.

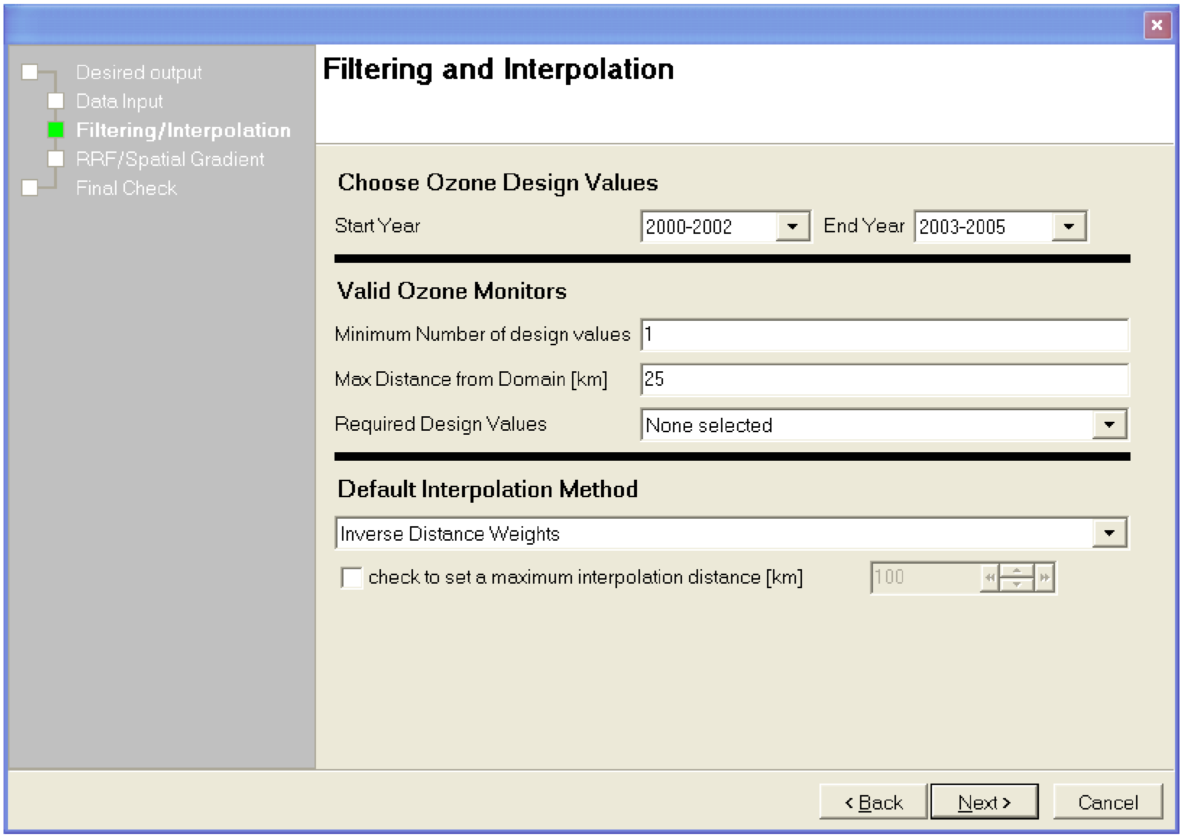



The **Data Input** window lets you specify the data files that you want to use. MATS comes populated with default data sets, but you can use your own data if you choose. The format for the data is in the Data Input section of the Ozone Analysis: Details chapter.

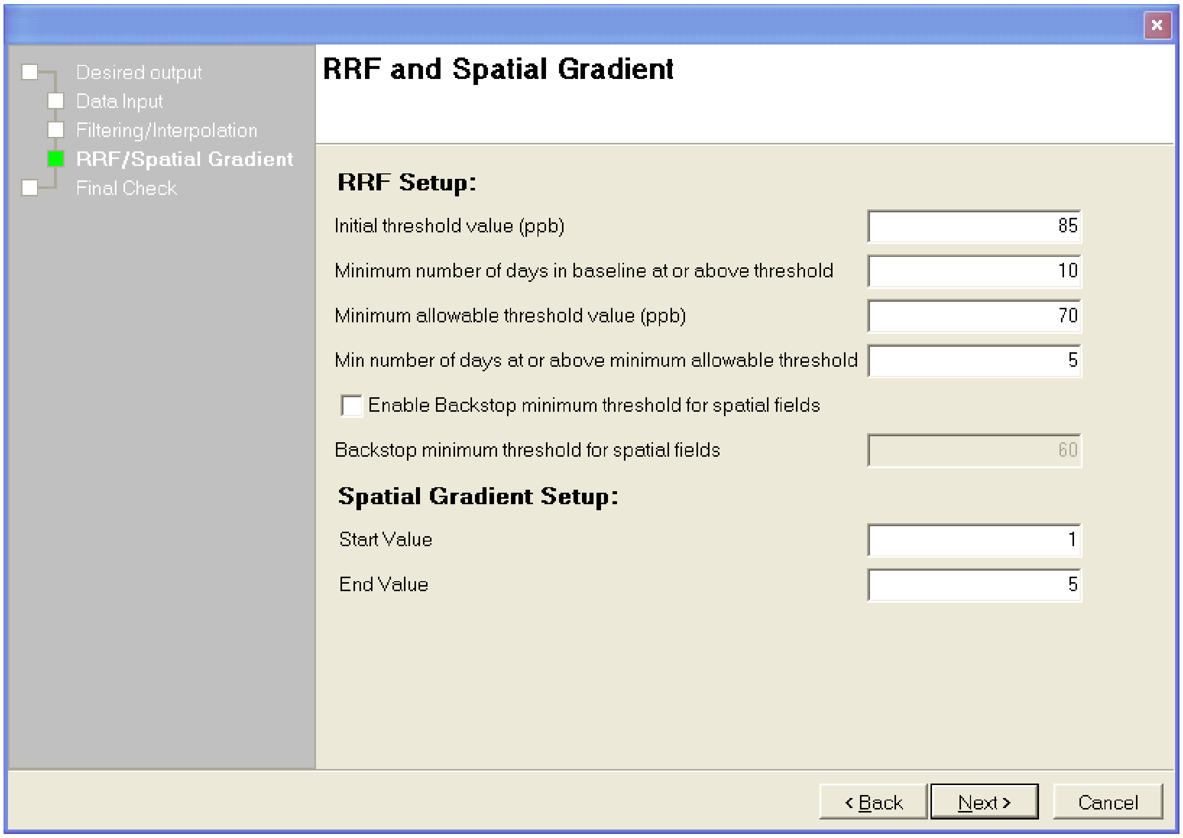
The **Data Input** window also lets you choose how to use model data when calculating a temporal adjustment at a monitor. This is discussed in detail in the Using Model Data section of the Ozone Analysis: Details chapter.



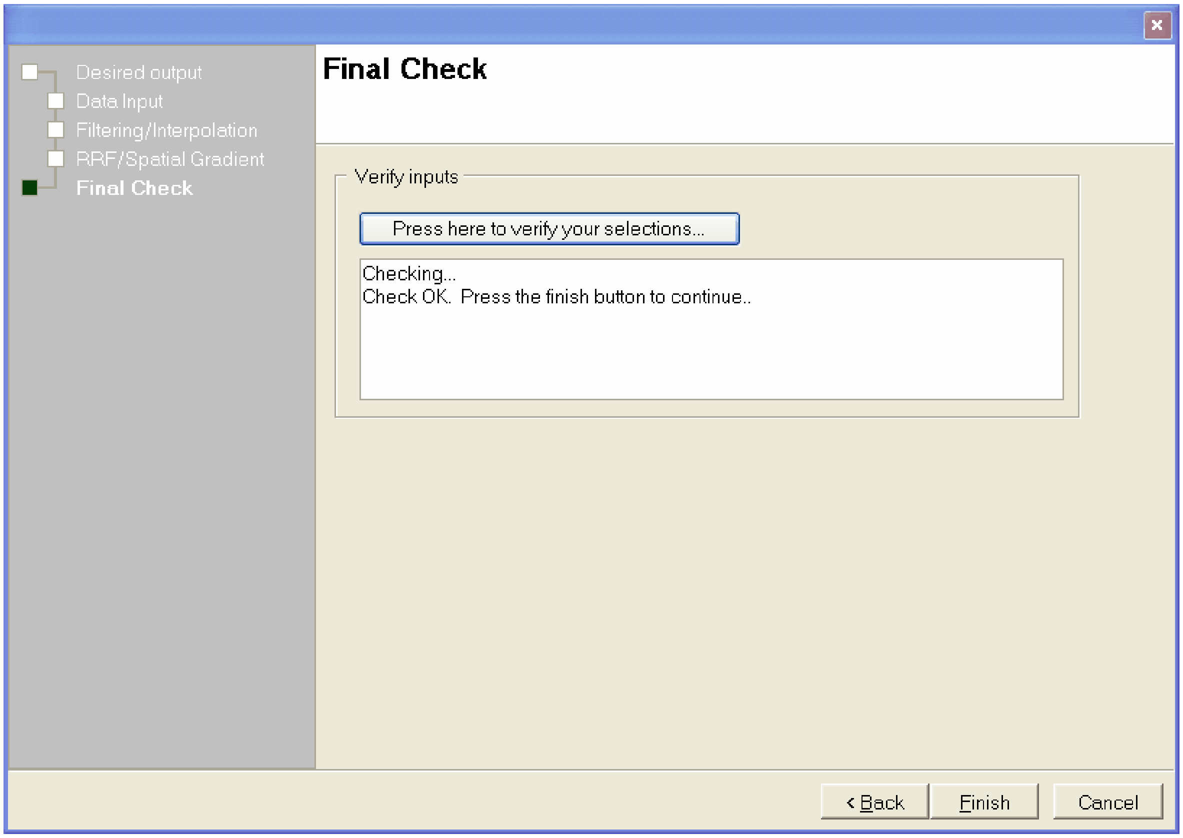

The **Filtering and Interpolation** window lets you specify the years of data that you want to use, any restrictions you want to apply when choosing valid monitors (*i.e.*, monitors that MATS use in its calculations), and options on the interpolation method. This is discussed in detail in the Filtering and Interpolation section of the Ozone Analysis: Details chapter.




The **RRF and Spatial Gradient** window lets you set parameters used in the calculation of relative response factors (RRF) and spatial gradients. This is discussed in detail in the RRF and Spatial Gradient section of the Ozone Analysis: Details chapter.

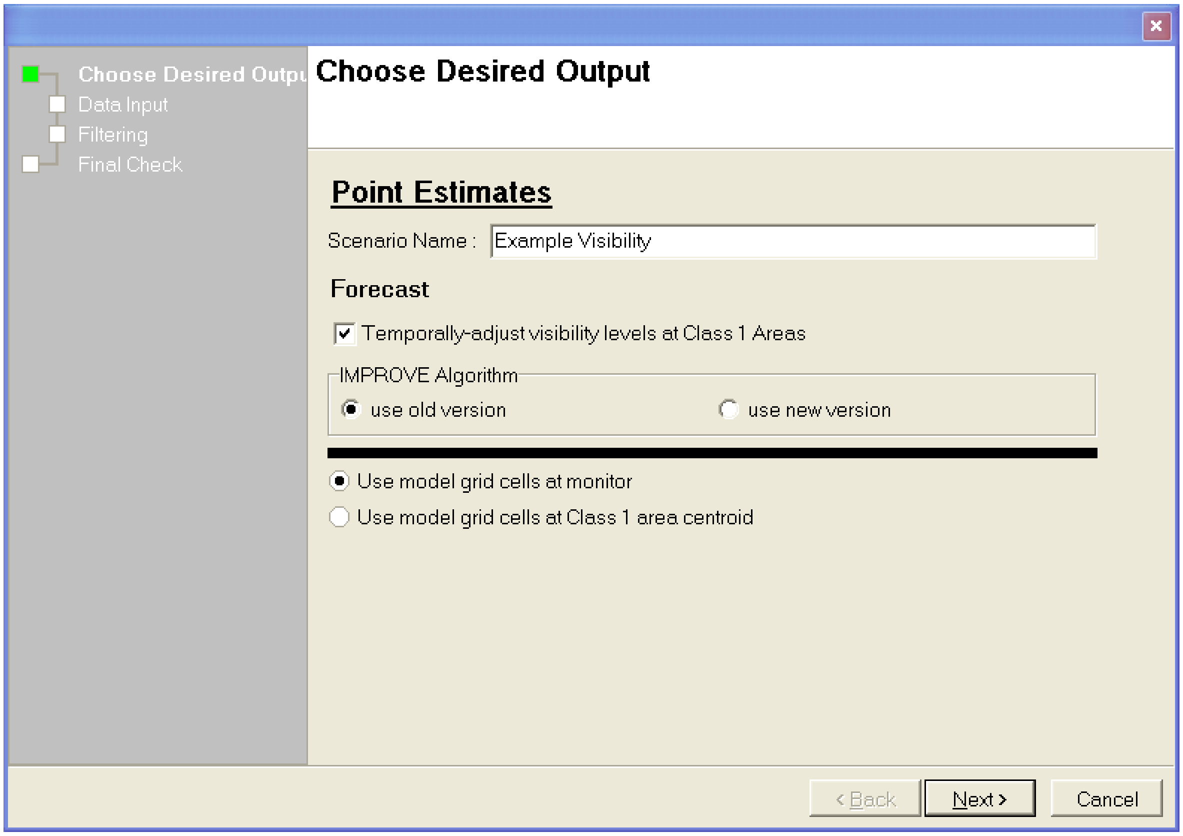



The last step is to verify the inputs to the analysis.



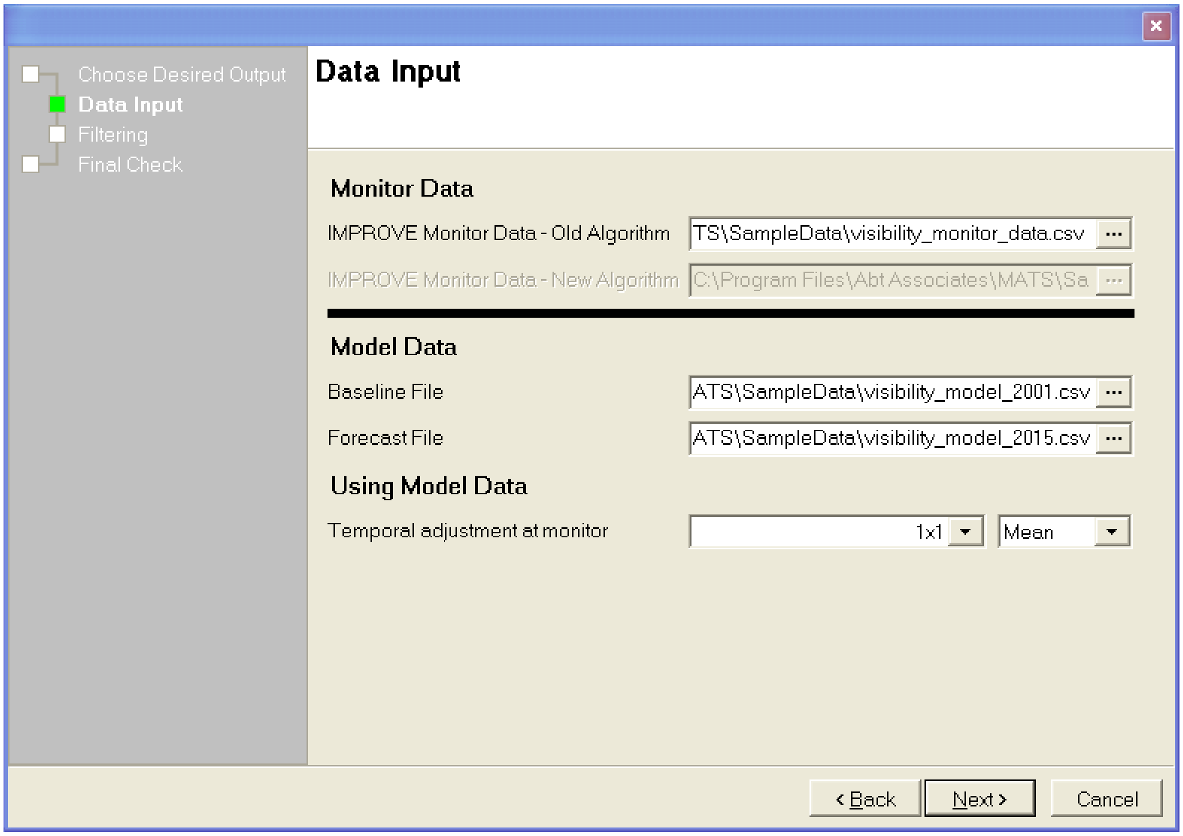

### 3.1.3 Visibility Analysis

MATS can forecast visibility in Class I Areas - these forecasts are referred to as Point Estimates. In addition to specifying the Scenario Name, you can choose the version of the **IMPROVE Algorithm** that you want to use. You can also choose whether to use model data at the monitor linked to each Class I Area, or whether to use model data closest to the Class I Area centroid. These different assumption are discussed in the Desired Output section of the Visibility Analysis: Details chapter.

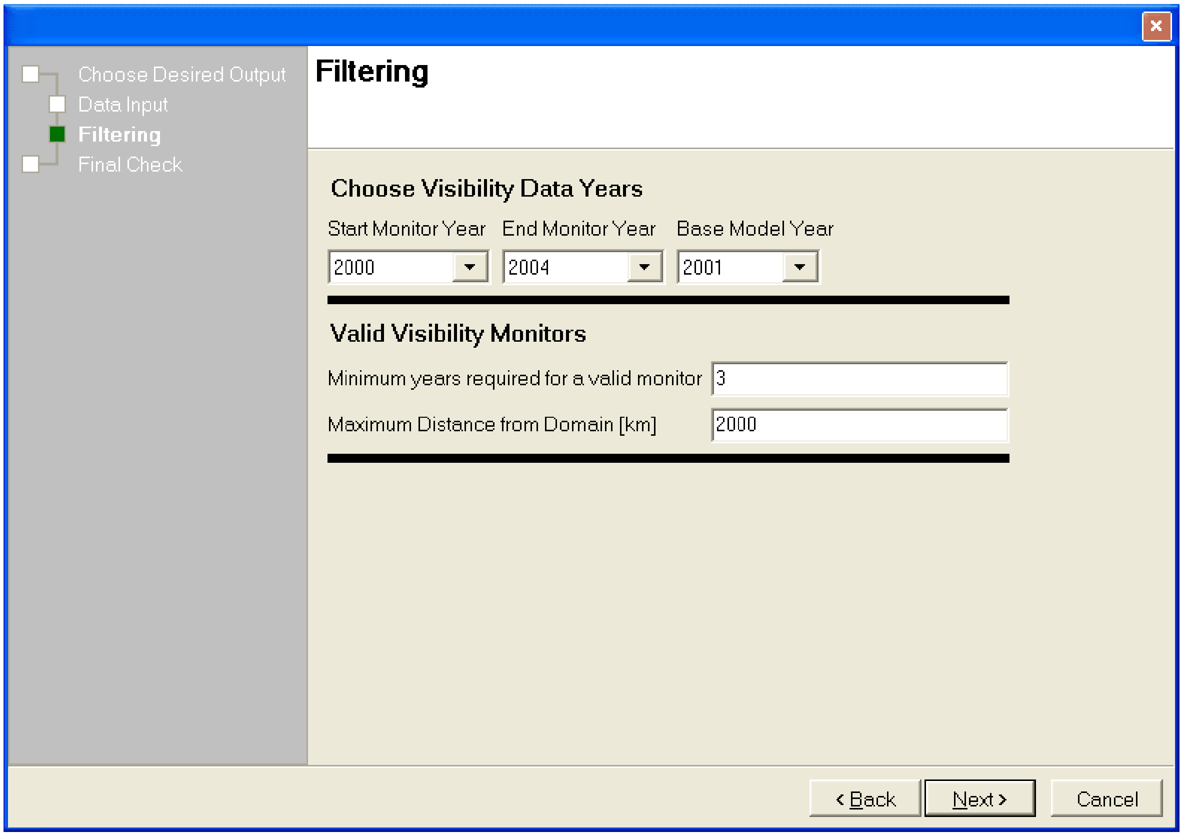



The **Data Input** window lets you specify the data files that you want to use. MATS comes populated with default input data, but you can use your own data if you choose. The format for the data is in the Data Input section of the Visibility Analysis: Details chapter.

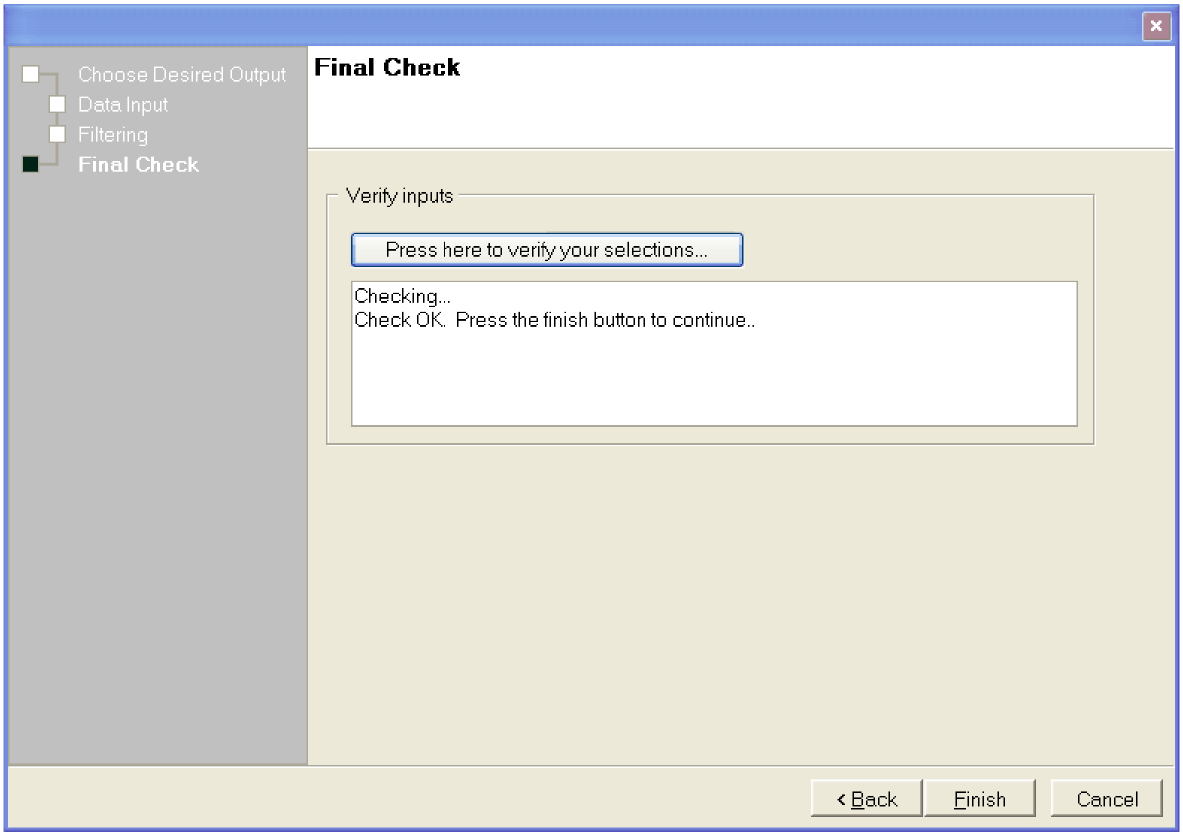
The **Data Input** window also lets you choose how to use model data when calculating a temporal adjustment at a monitor. This is discussed in detail in the Using Model Data section of the Visibility Analysis: Details chapter.




The **Filtering** window lets you specify the years of data that you want to use, and any restrictions you want to apply when choosing valid monitors (*i.e.*, monitors that MATS use in its calculations). This is discussed in detail in the Filtering section of the Visibility Analysis: Details chapter.



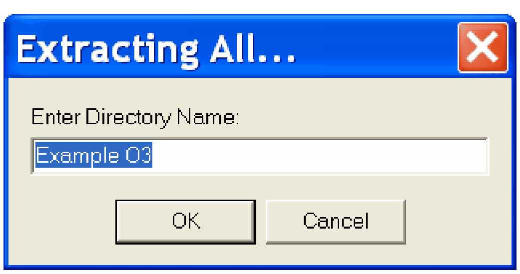

The last step is to verify the inputs to the analysis.




## 3.2 Output Navigator

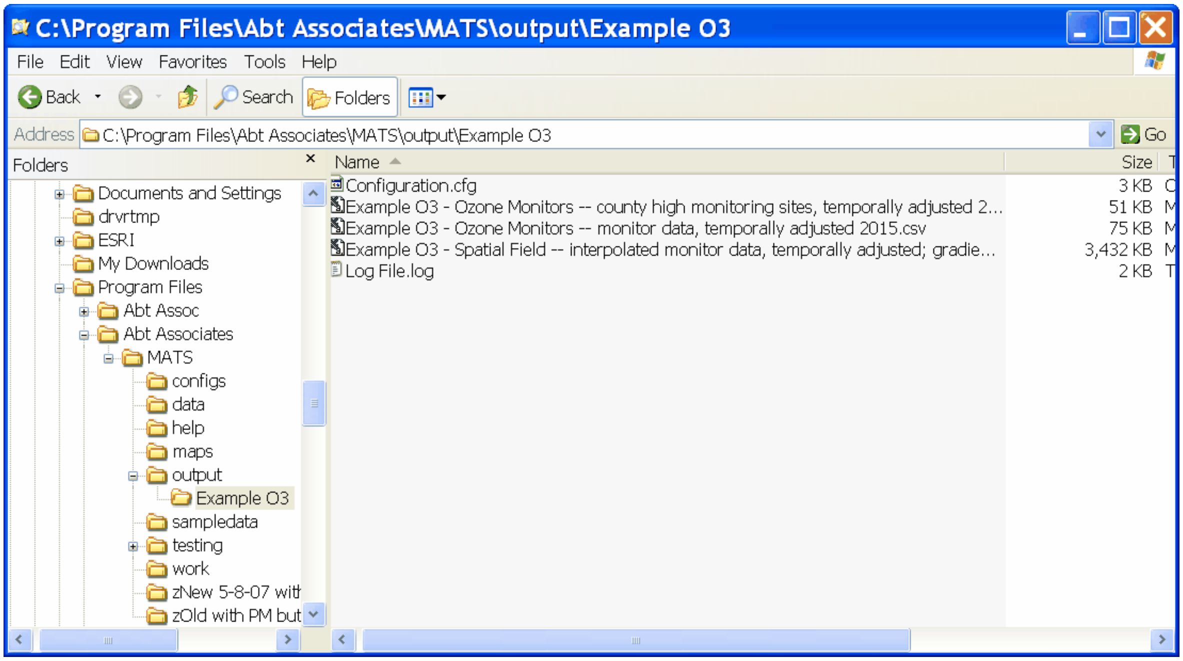
The **Output Navigator** allows you to load results files (*i.e.*, ASR files) that you have previously created in MATS. You can view these data in maps and in tables, or export the data to text files that you can then work with in a program such as Excel.

To start, just click on the **Output Navigator** tab. Then click on the **Load** button to choose the file that you want to examine. You can click the **Extract All** button, and MATS will create a folder with all of the files that MATS has generated. (A default name for the folder is the Scenario Name you have chosen.)

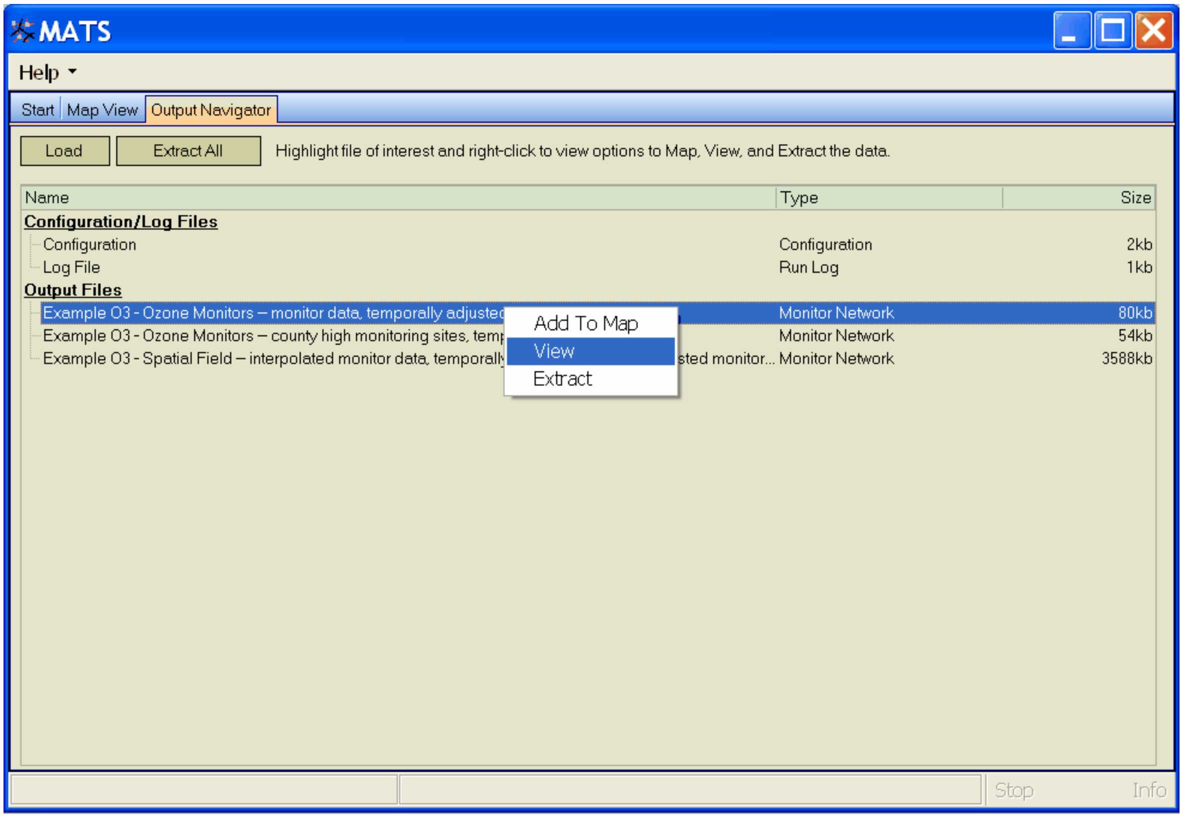



The files generated by MATS are of two types: (1) Configuration and Log files; and (2)

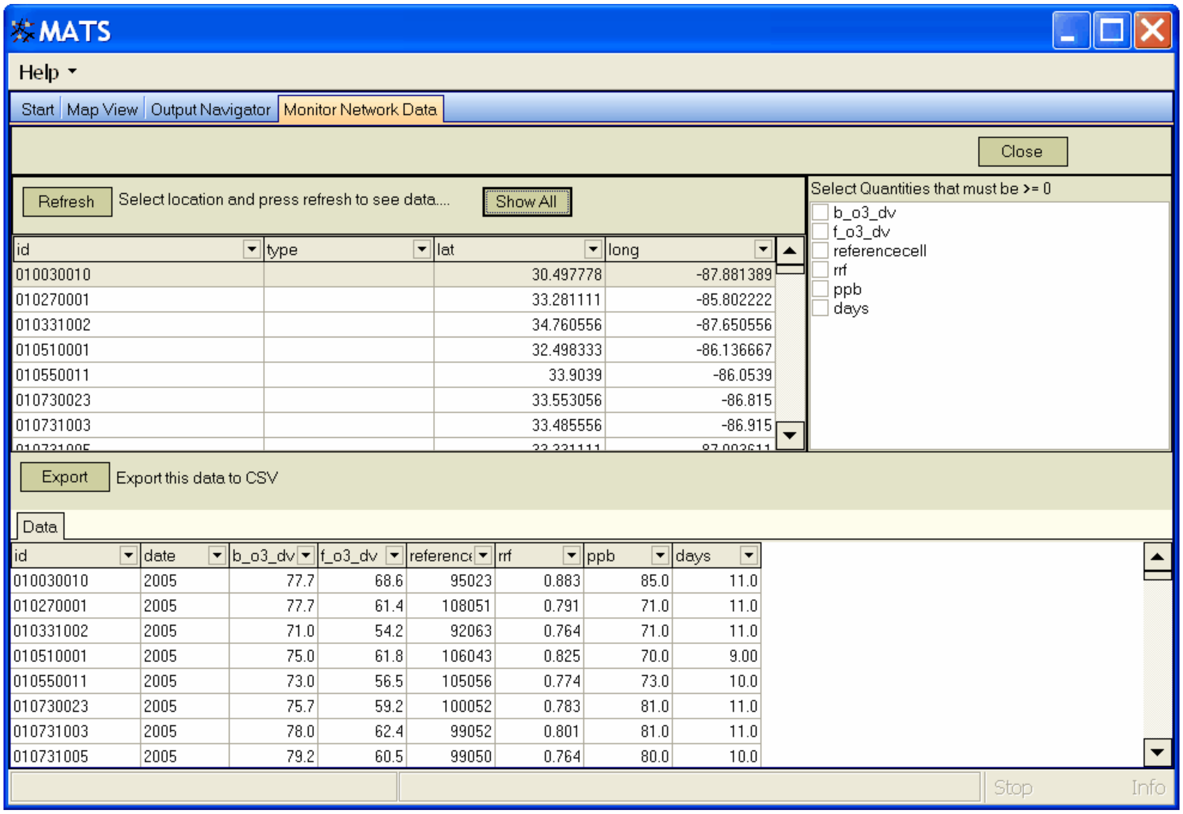
Output files containing the results of the MATS calculations.



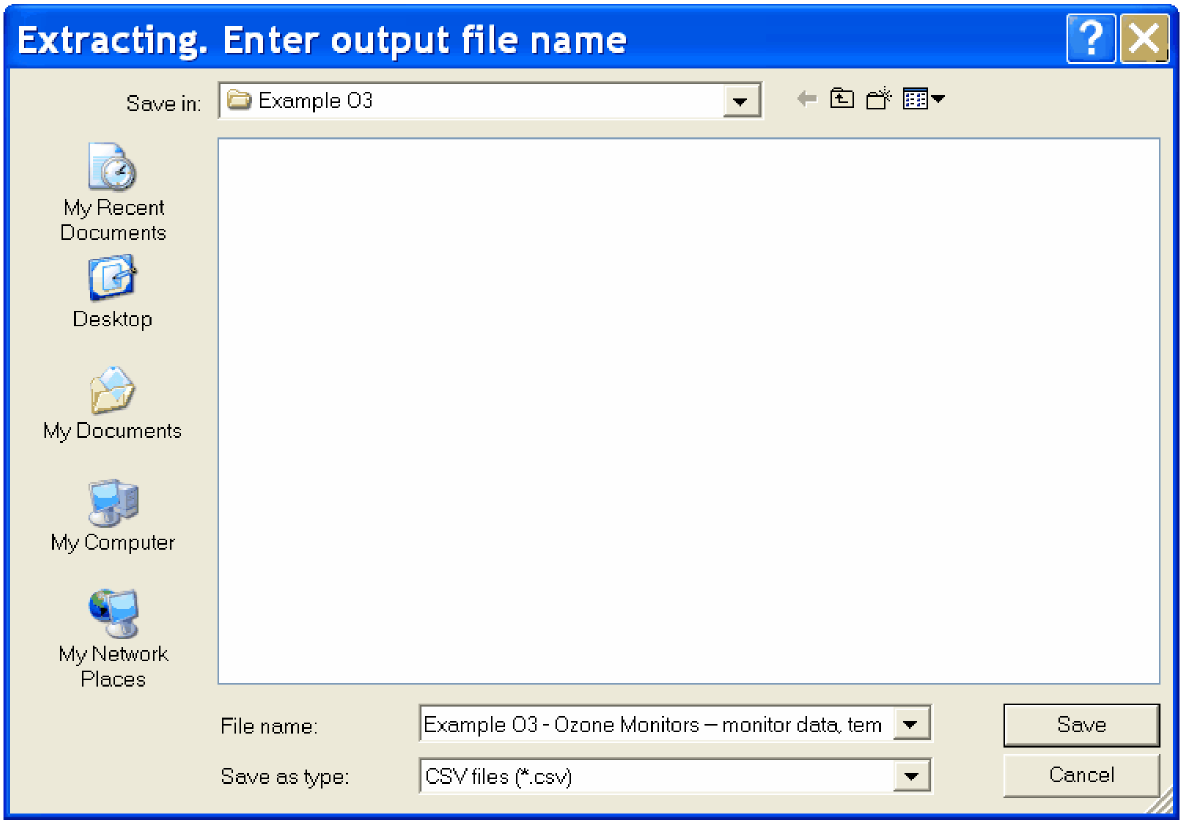

Another option is to right-click on a particular file, and then you can choose whether to use data to *Add to Map*, *View*, or *Extract*.




The *View* option lets you examine the data and then to export it to a CSV file, which you can then load into another program such as Microsoft Excel.



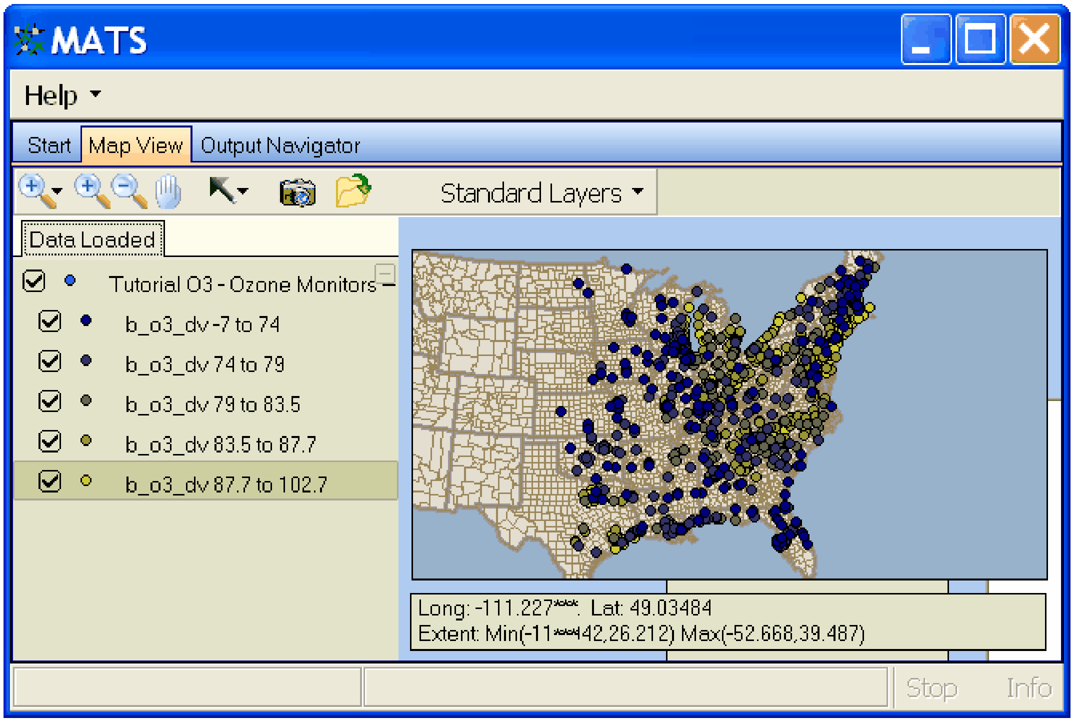

Choosing the *Extract* option will allow you to immediately export the data to a CSV file. The default file name for the CSV file is the same one that you see in the Output Navigator window (*e.g.*, *Example O3 - Ozone Monitors -- monitor data.csv*).




Choosing the *Add to Map* option allows you to create a map of your results.

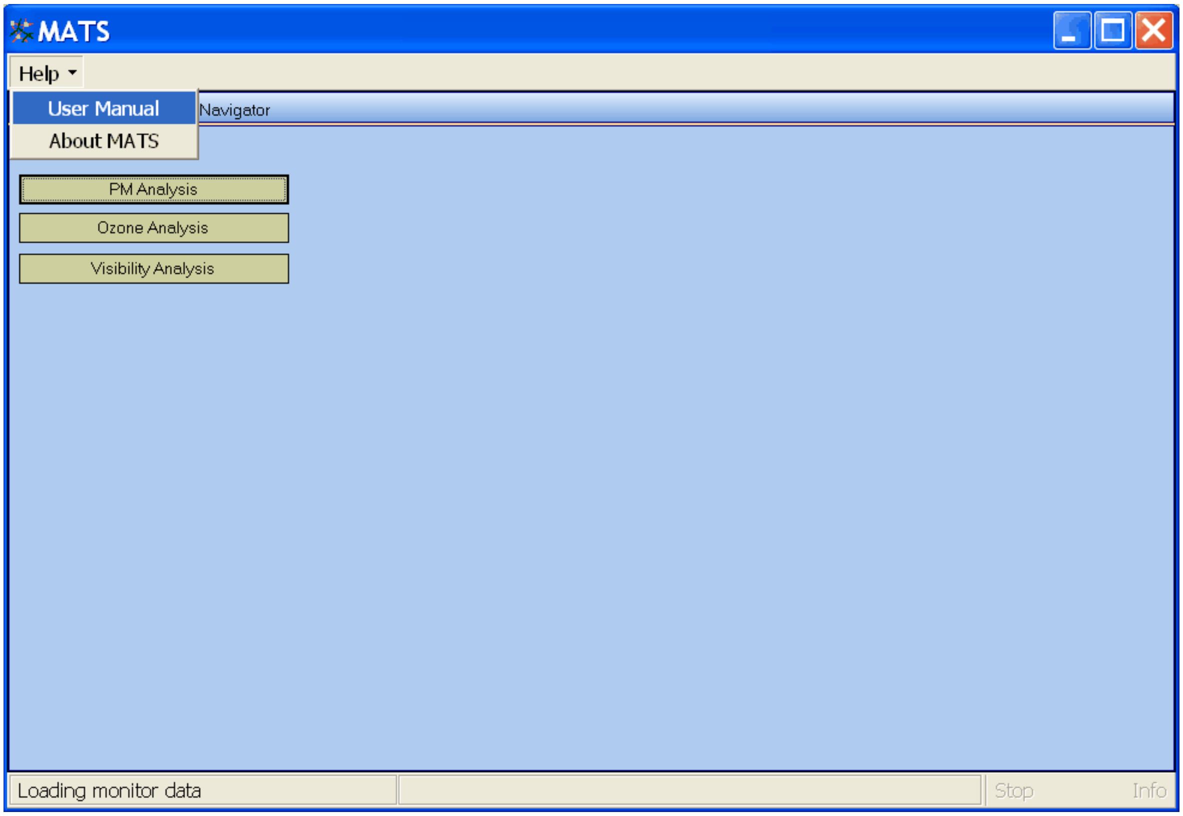
## 3.3 Map View

The **Map View** allows you to perform a variety of mapping tasks. You can zoom in to a particular location; choose particular colors to map your data, export the maps you have created to BMP files, among other things. These various options are discussed in detail in the Map View chapter.




## 3.4 Help

The Help dropdown menu has the User Manual for MATS and version information.


MATS
Help
User Manual
About MATS
Navigator
PM Analysis
Ozone Analysis
Visibility Analysis
Loading monitor data
Stop
Info

# 4 PM Analysis: Quick Start Tutorial

< To be added. >

# 5 PM Analysis: Details

< To be added. >

# 6 Ozone Analysis: Quick Start Tutorial

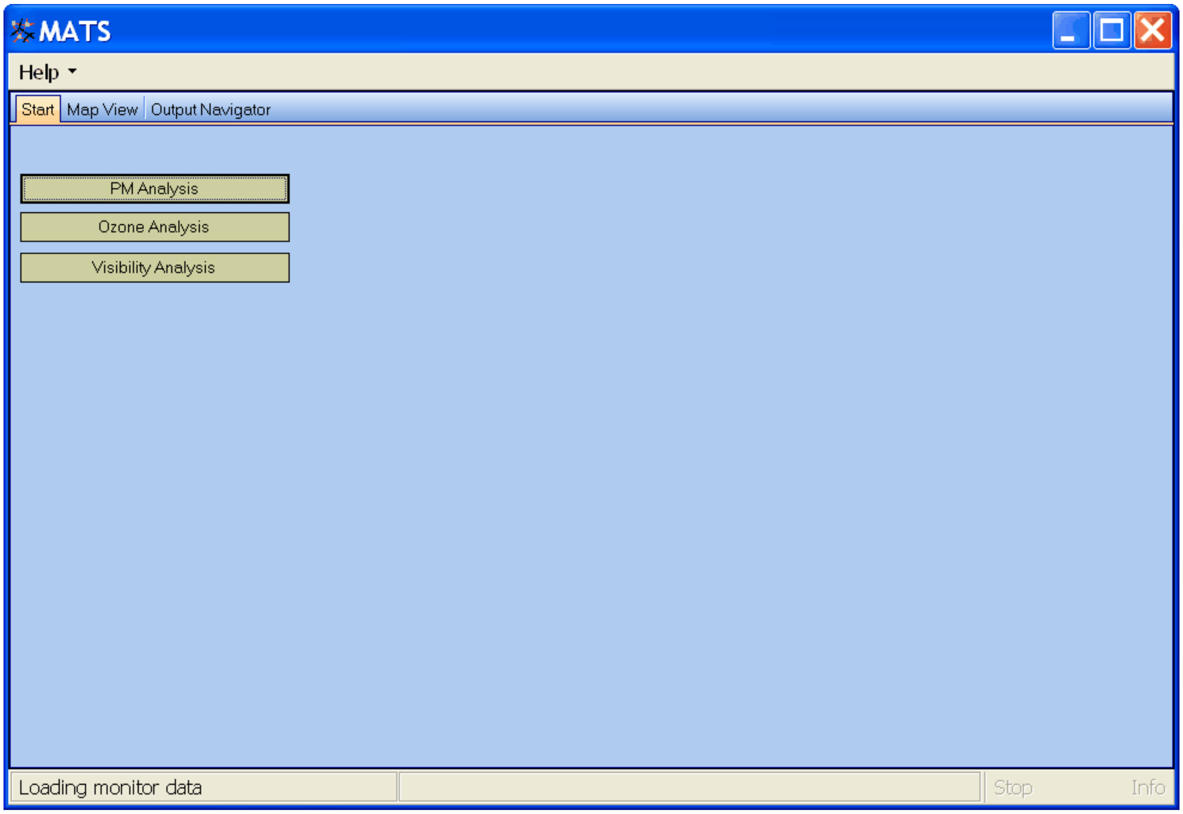
In this tutorial you will forecast ozone design values at monitors in the Eastern United States. The steps in this analysis are as follows:

- Step 1. Start MATS. Start the MATS program and choose to do an Ozone analysis.
- Step 2. Desired Output. Choose the output to generate. In this example, you will forecast ozone levels at monitor locations.
- Step 3. Data Input. Choose the data files for input to MATS.
- Step 4. Filtering & Interpolation. Choose the particular years of data and monitors to use in this analysis.
- Step 5. RRF & Spatial Gradient. Specify how to generate the relative response factors (RRFs) used in the forecasts.
- Step 6. Final Check. Verify the choices you have made.
- Step 7. Load & Map Results. Load your results and prepare maps of your forecasts.
- Step 8. View & Export Results. Examine the data in a table format and export these data.

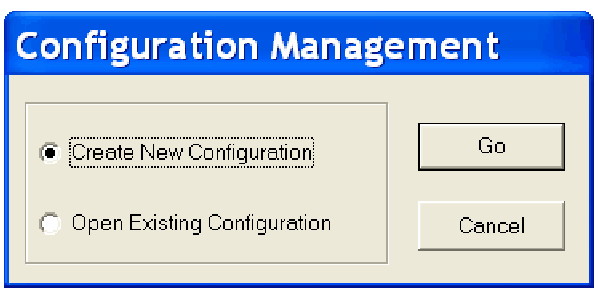
Each step is explained in detail below.

## 6.1 Step 1. Start MATS

Double-click on the MATS icon on your desktop, and the following window will appear:




Click the **Ozone Analysis** button on the main MATS window. This will bring up the **Configuration Management** window.



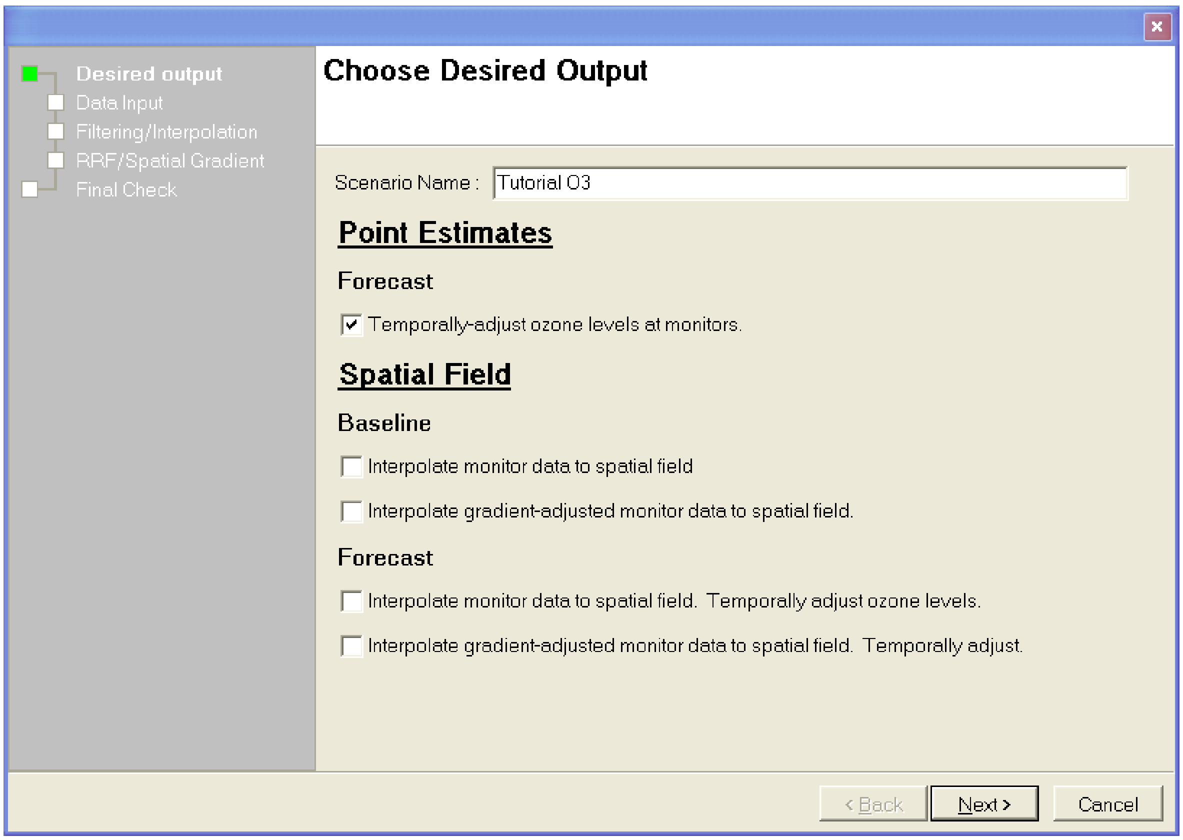

A Configuration allows you to keep track of the choices that you make when using MATS. For example, after generating results in MATS, you can go back, change one of your choices, rerun your analysis, and then see the impact of this change without having to enter in all of your other choices. For this example, we will start with a *New Configuration*.

Choose **Create New Configuration** and click the **Go** button. This will bring up the Choose Desired Output window.

## 6.2 Step 2. Desired Output .

The **Choose Desired Output** window allows you to choose the output that you would like to generate. MATS allows you to forecast Point Estimates (at ambient monitors) or to generate a Spatial Field of either Baseline values or Forecast values.

In the **Scenario Name** box type "*Tutorial O3*" – this will be used to keep track of where your results are stored and the variable names used in your results files. Leave the box checked next to Temporally-adjust ozone levels at monitors**.** MATS will create forecasts for each monitor in the monitor file.



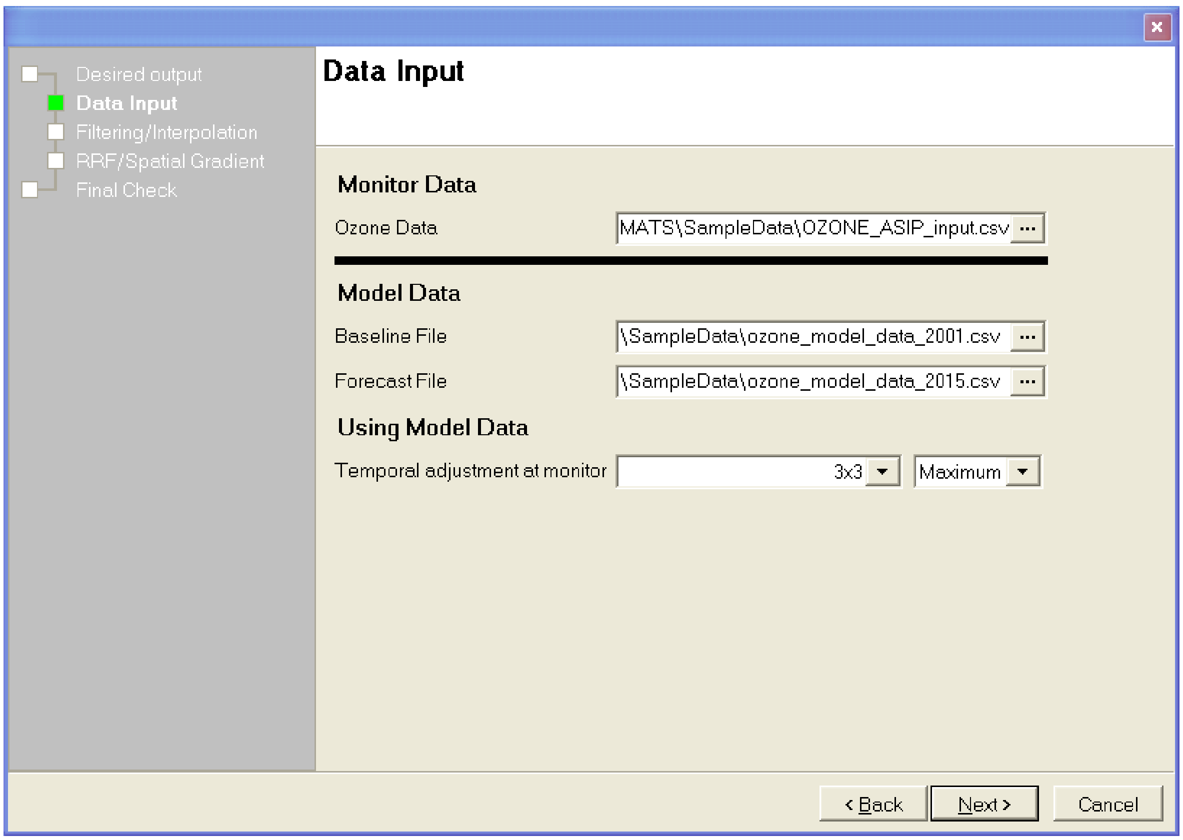

When your window looks like the window above, click **Next**. This will bring you to the Data Input window.

## 6.3 Step 3. Data Input

The **Data Input** window allows you to choose the monitor data and the model data that you want to use. As discussed in more detail in the following chapter (see RRF Setup), MATS calculates the ratio of the base and future year model data to calculate a relative response factor (RRF). MATS then multiplies the design value from the monitor data with the RRF to calculate a future-year design value.

MATS currently comes loaded with ozone design values for the period from 1997-2005 (1997-1999, 1998-2000, 1999-2001, 2000-2002, 2001-2003, 2002-2004, and 2003-2005); and it comes loaded with example ozone model data for 2001 and 2015. These are the files needed to calculate the Point Estimates and Spatial Fields listed in the Desired Output window.

Use the default settings in the **Data Input** window. The window should look like the following:




Note that MATS gives you the option to use model data in different ways when calculating forecasts at each monitor. The user can choose to use the model results from the single grid cell that contains the monitor or select a grid cell array of 3x3, 5x5, or 7x7 model cells around each monitor. The example model output dataset contained in MATS is at 12km resolution. Therefore, for this example, a 3x3 grid cell array should be used (see section 3.2 of the modeling guidance). The default for ozone analysis is to choose the maximum value each day in the array for the calculation. This is described in more detail in the Using Model Data section of the Ozone Analysis: Details chapter.

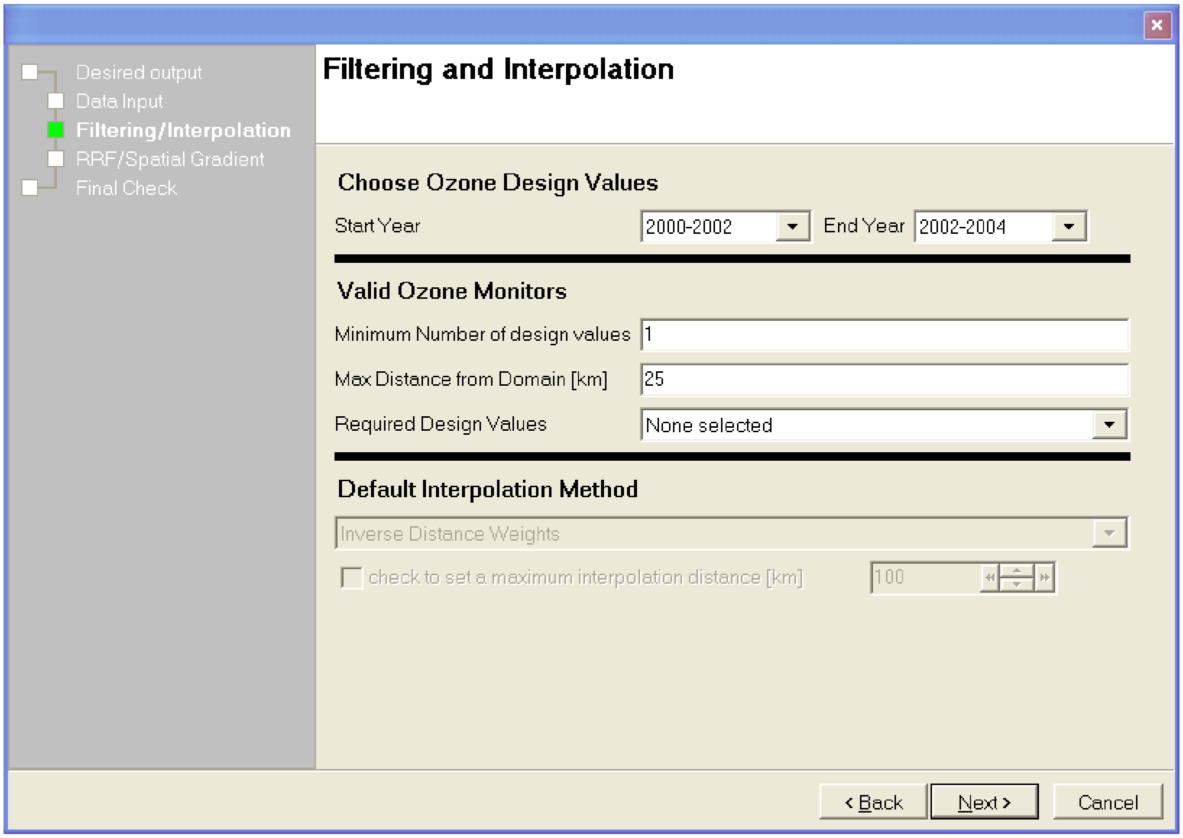
When your window looks like the window above, click **Next**. This will bring you to the

Filtering and Interpolation window.

## 6.4 Step 4. Filtering and Interpolation

The **Filtering and Interpolation** window has several functions. These include identifying the years of monitor data that you want to use, choosing the particular monitors in these data that you want in your analysis, and (when calculating spatial fields) specifying the interpolation method. Use the default settings pictured in the screenshot below.

- Choose Ozone Design Values. Choose the years of design values that you want to use. The default is to use a 5 year period (3 design values) that is centered about the base emissions year. The default in MATS assumes an emissions year of 2002. Therefore, the design value would be based on data from 2000-2002 up through a design value based on data from 2002-2004. (That is, the **Start Year** is *2000-2002* and the **End Year** is *2002-2004*.)
- Valid Ozone Monitors. Identify "valid" monitors -- that is, those monitors that you want to include in the analysis. The defaults are that monitors should have at least one valid design value period; and, are within 25 kilometers of a model grid cell. You can also specify that a monitor must have a particular design value (*e.g.*, 2000-2002) to be valid, however the default is to require none in particular.
- Default Interpolation Method. Choose the interpolation method -- that is, the method to combine the design values from different monitors into a single estimated design value. This option is only used when generating estimates for a Spatial Field. Since we are only generating Point Estimates, this set of options is not active.

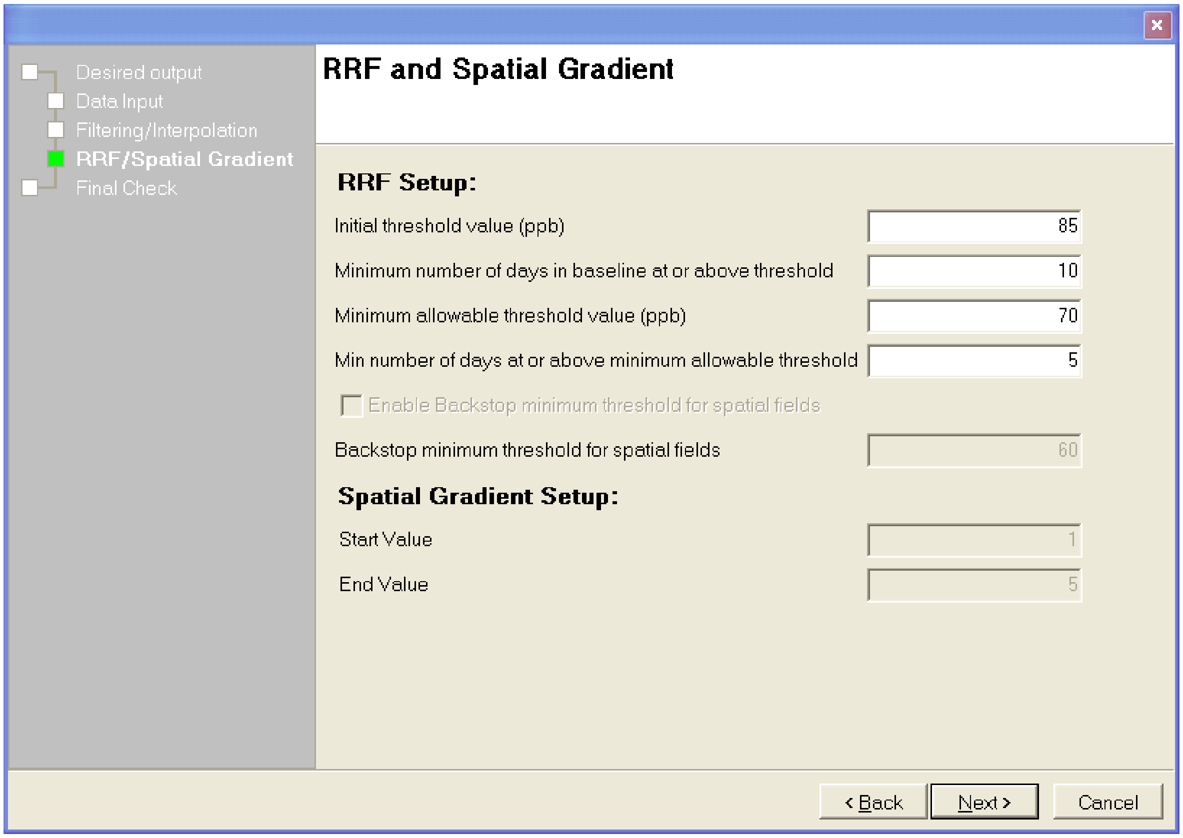



When your window looks like the window above, click **Next**. This will bring you to the RRF & Spatial Gradient window, where you can set parameters for the calculation of RRFs and spatial gradients.

## 6.5 Step 5. RRF & Spatial Gradient

The RRF and Spatial Gradient window has two sets of options.

- The **RRF Setup** uses threshold values in the model data to identify the days to be used in the calculation of relative response factors (RRFs). The details of this process are somewhat involved and are described in detail in the next chapter. (See: the example calculations.) A brief summary is the following: The default threshold is set to 85 ppb.* If there are fewer than 10 model days at or above 85 ppb in the baseline scenario, then MATS will lower the threshold in increments of 1 ppb, until there are at least 10 days at or above this new, lower threshold. This process is continued, if needed, until a threshold of 70 ppb is reached. By default, this is the lowest allowable threshold. If there are fewer than 5 days at or above this threshold of 70 ppb, then the monitor site will be dropped.
- The **Spatial Gradient Setup** identifies the model values that will be used in the calculation of a Spatial Field. Since we are only generating Point Estimates, this set of options is not active.




When your window looks like the window above, click **Next**. This will take you to the Final Check window, where you can verify the choices that you have made.

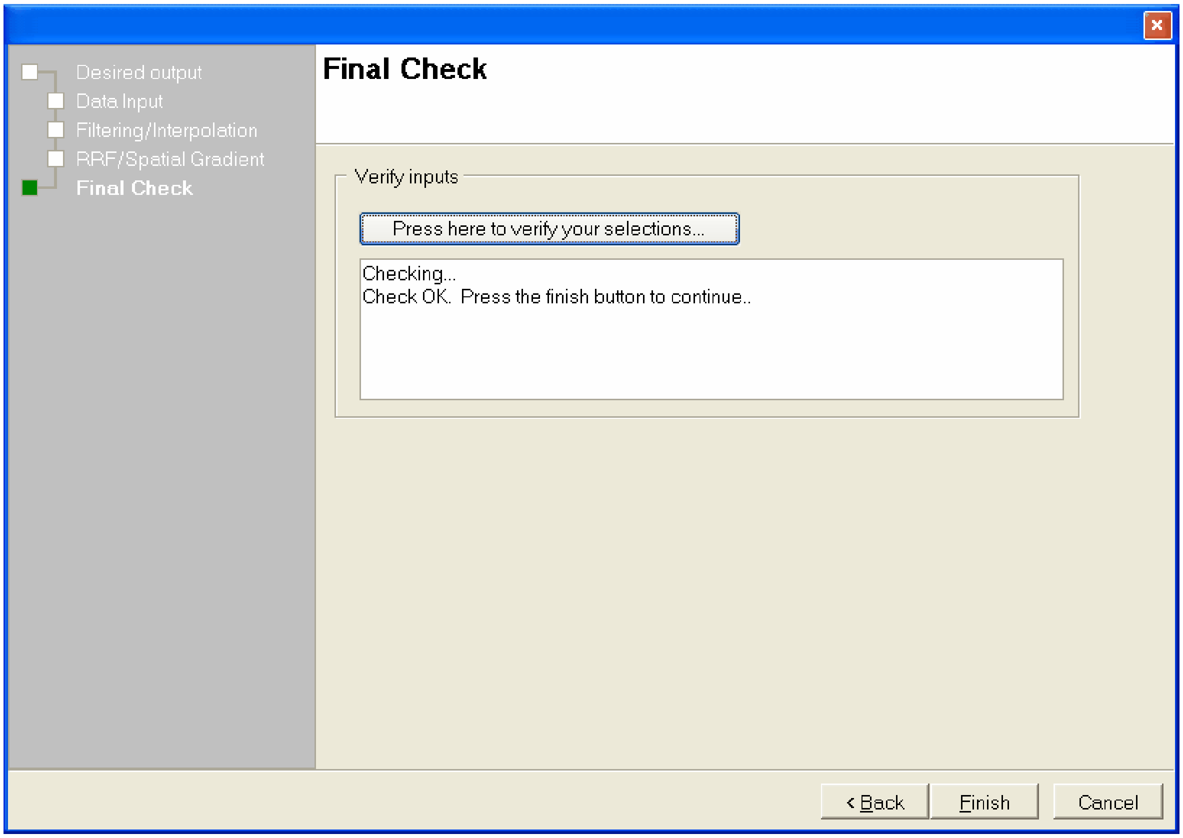
---

* The default values in MATS are consistent with the recommended values in the EPA modeling guidance (see section 14.1.1).

## 6.6 Step 6. Final Check

The **Final Check** window verifies the choices that you have made. For example, it makes sure that the paths specified to each of the files used in your Configuration are valid.

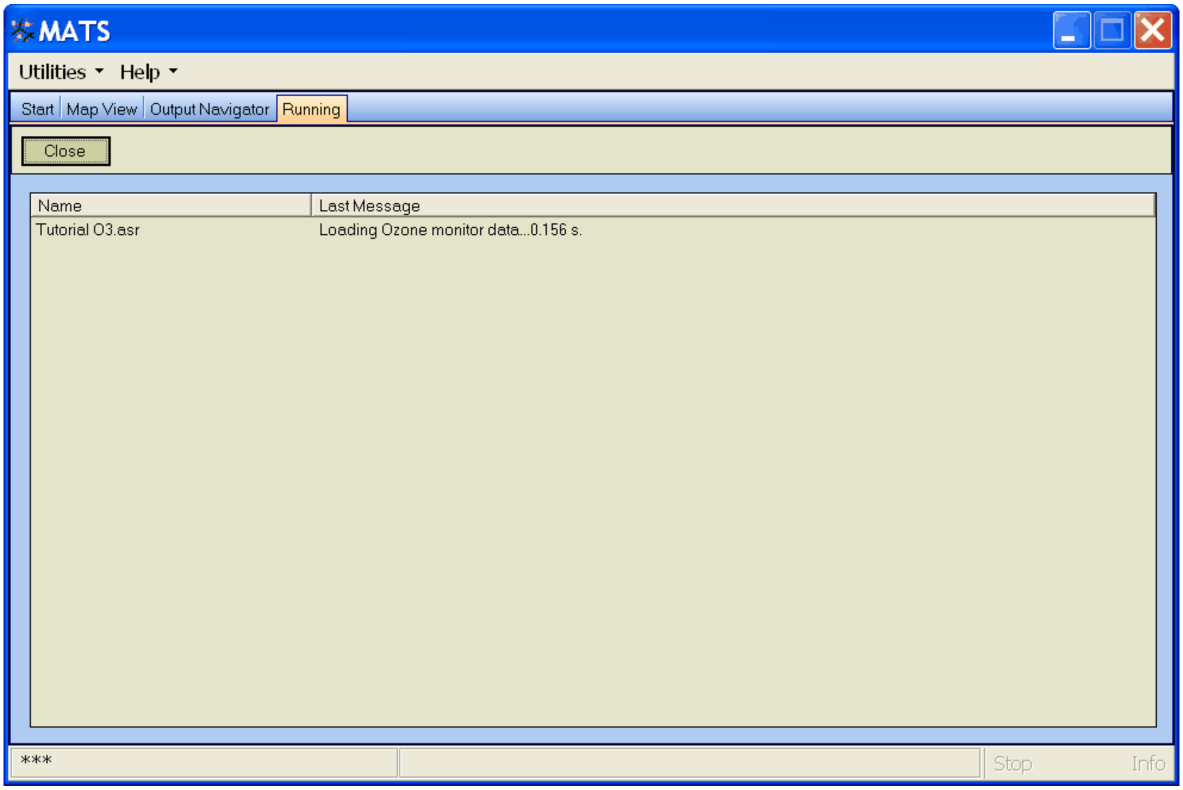
Click on the **Press here to verify selections** button.



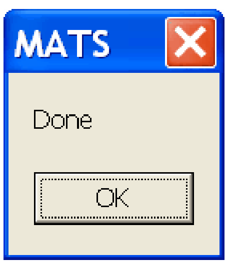

If you encounter any errors, go back to the choices you have previously made by clicking on the appropriate part (**e.g.**, Data Input) of the tree in the left panel, and then make any changes required.

When your window looks like the window above, click **Finish**.

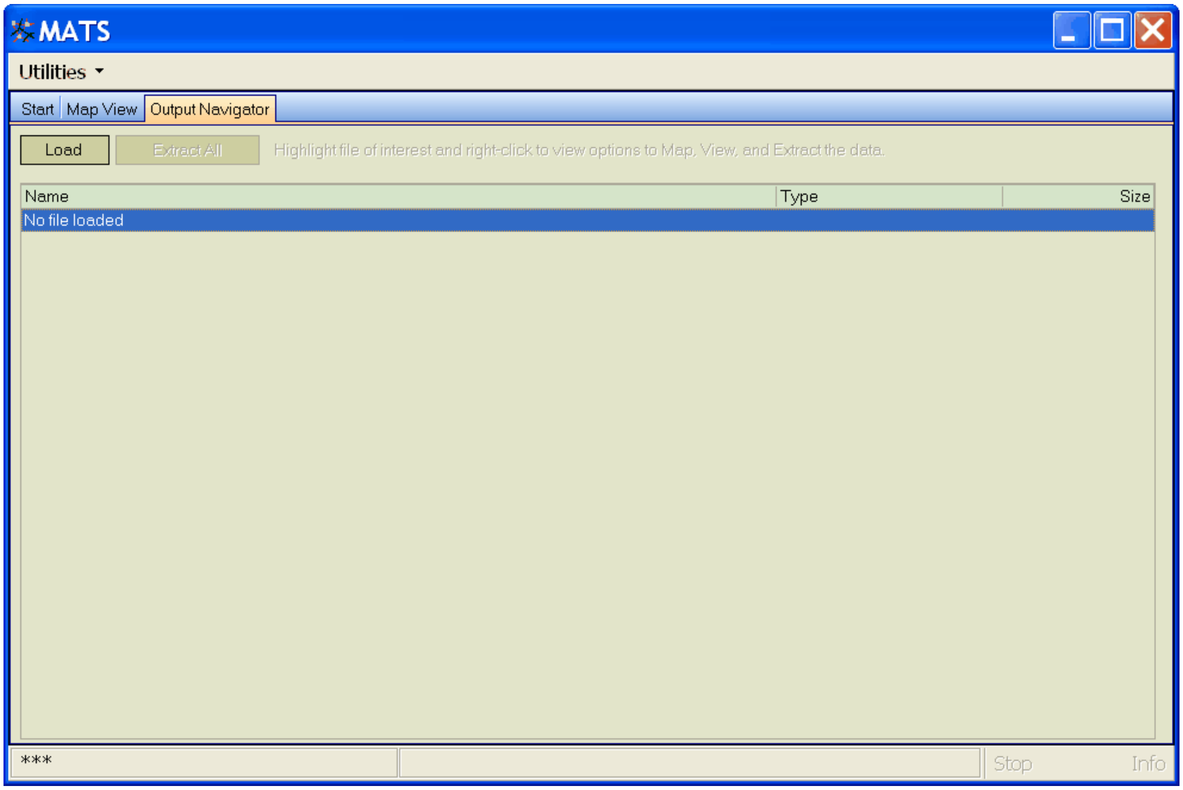
A temporary, new **Running** tab will appear (in addition to the **Start**, Map View and Output Navigator tabs).




When the calculations are complete, a small window indicating the results are **Done** will appear. Click **OK**.



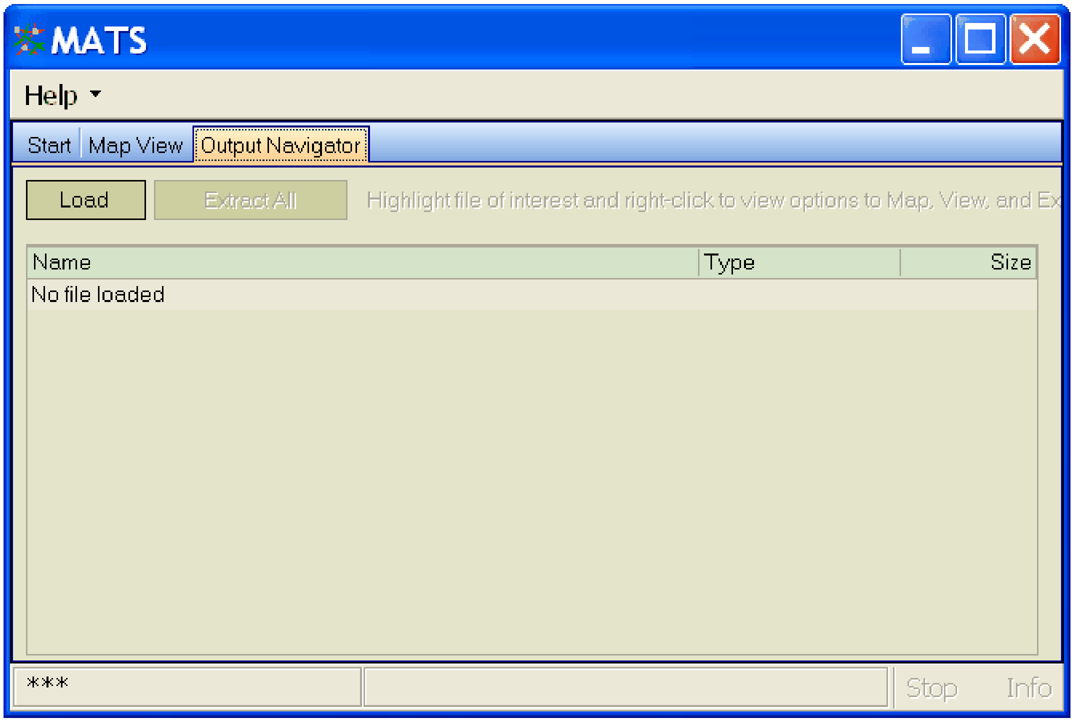

After clicking **OK**, the **Output Navigator** tab will be active. (The **Running** tab will no longer be seen.)



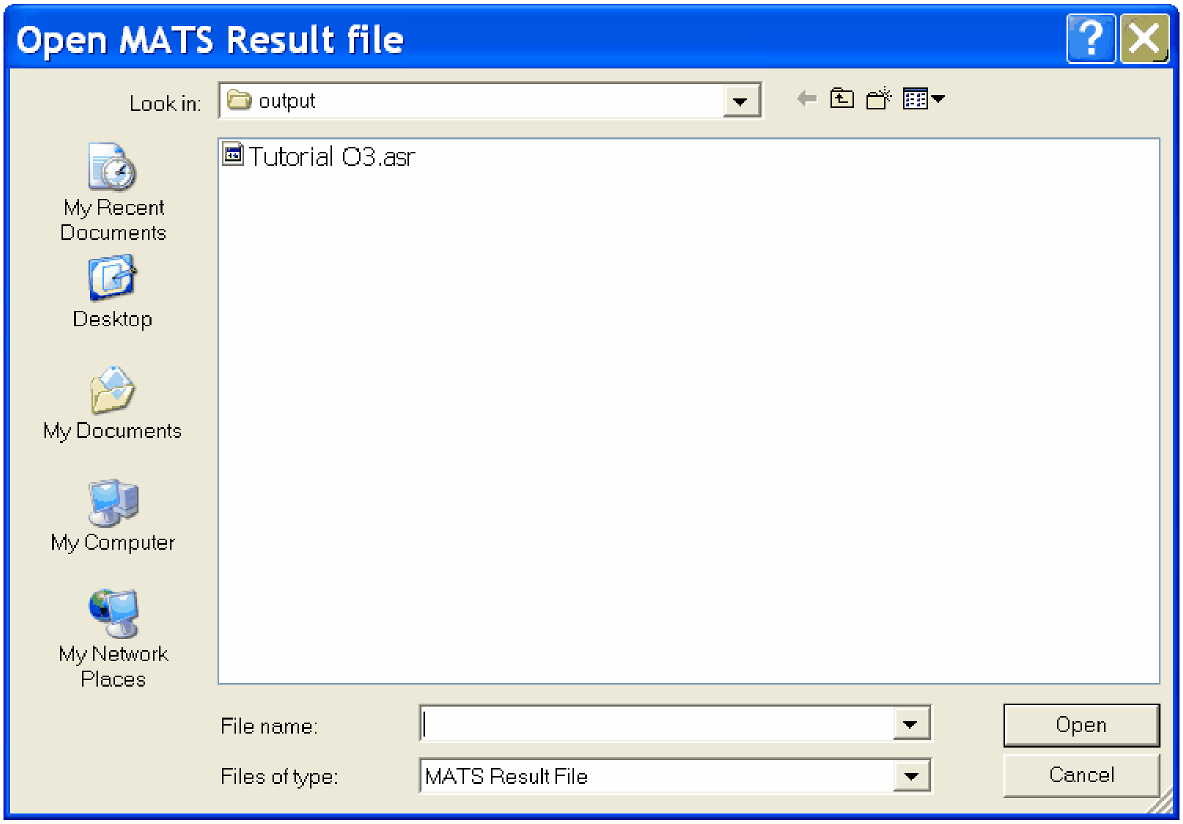

The next step (click here) shows you how to map your results with the **Output Navigator**. For more details on mapping and other aspects of the **Output Navigator**, there is a separate chapter on the Output Navigator.

## 6.7 Step 7. Load & Map Results

After generating your results, the next step is to use the Output Navigator to load and map them.




Click on the **Load** button and choose the *Tutorial O3.asr* file.



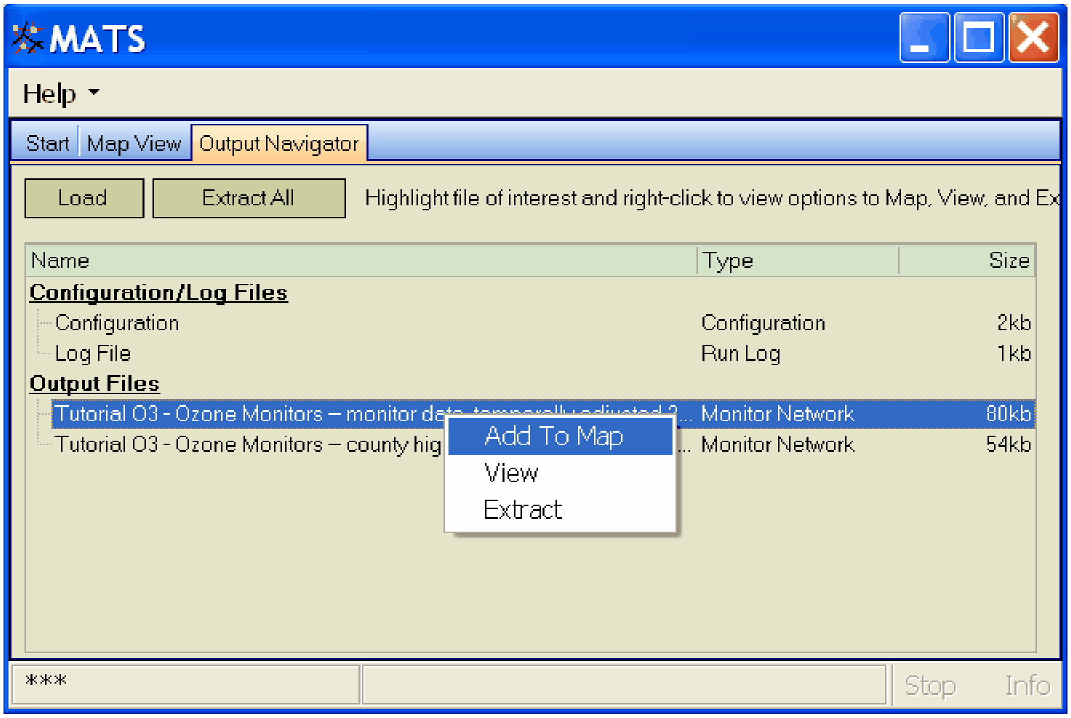

Under **Configuration/Log Files**, you will see two files:

- *Configuration*: keeps track of the assumptions that you have made in your analysis.
- *Log File*: provides information on a variety of technical aspects regarding how a results file (*.ASR) was created.

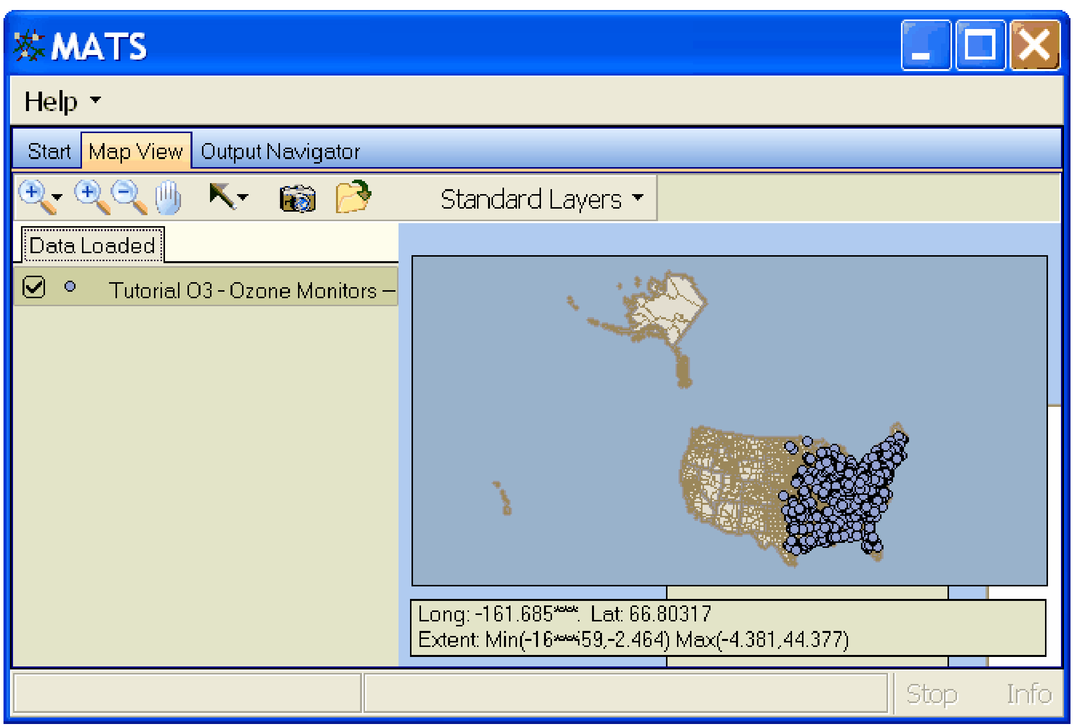
Under **Output Files** you will see:

- *Tutorial O3 - Ozone Monitors - monitor data, temporally adjusted 2015*: contains forecasted values and the monitor data used.
- *Tutorial O3 - Ozone Monitors - county high monitoring sites, temporally adjusted 2015*: contains forecasted values and the monitor data used for the monitor with the highest levels in the county.

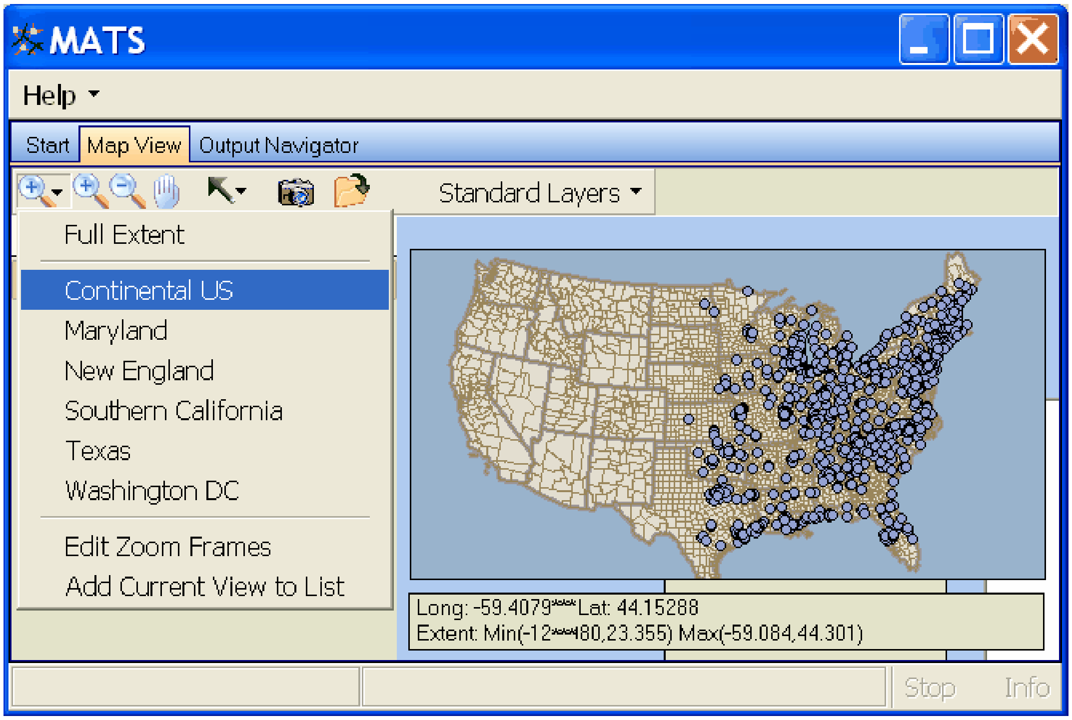
Right-click on the file *Tutorial O3 - Ozone Monitors - monitor data temporally adjusted 2015*. This gives you three options: *Add to Map*, *View*, and *Extract*. Choose the *Add to Map* option.



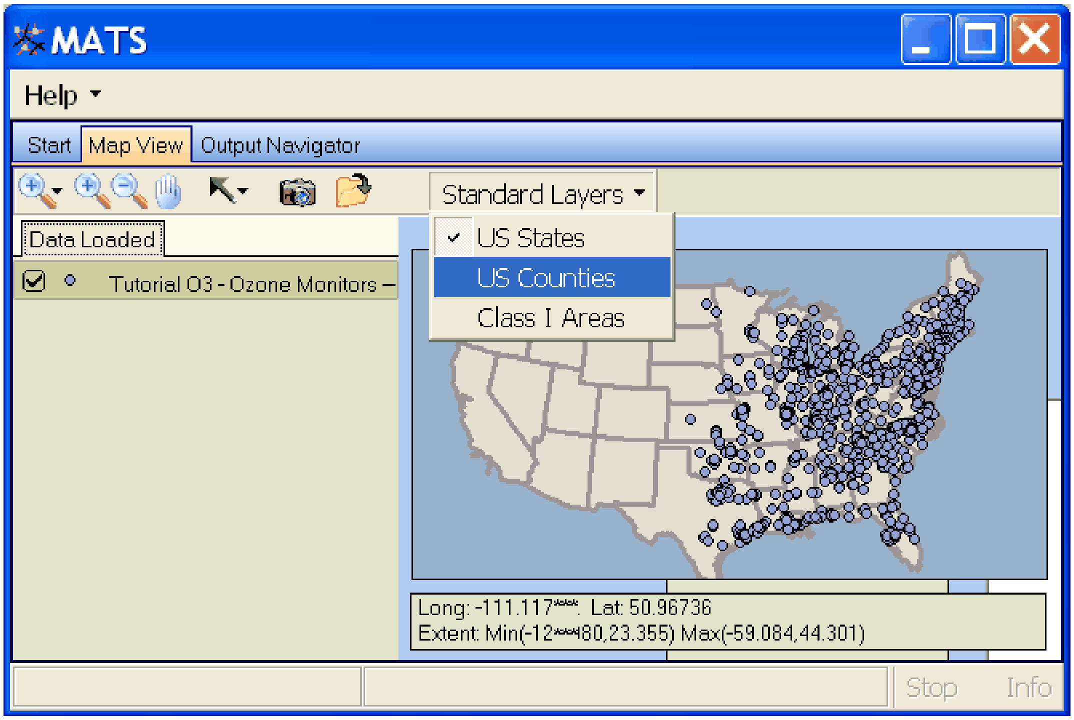

This will bring up the **Map View** tab.



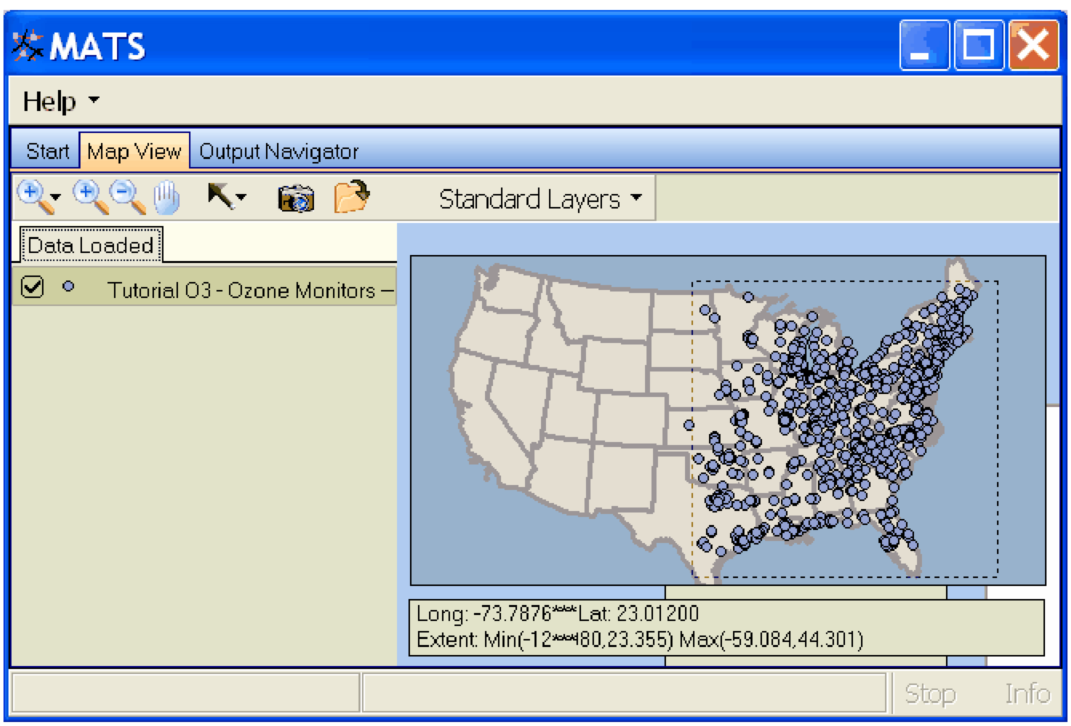
To view an enlarged map, use the **Zoom to an area** Task Bar button on the far left. Choose the *Continental US*.



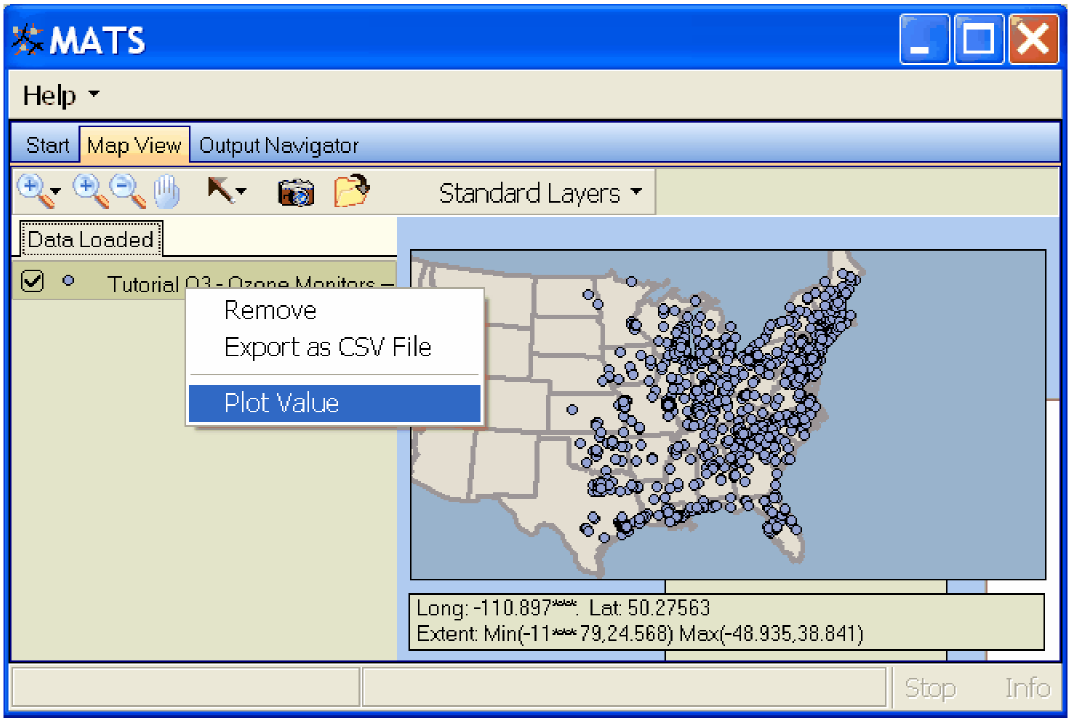

To more easily view the location of monitors in particular states, uncheck *US Counties* using the **Standard Layers** drop down menu on the far right of the Task Bar.  Your window should look like the following:



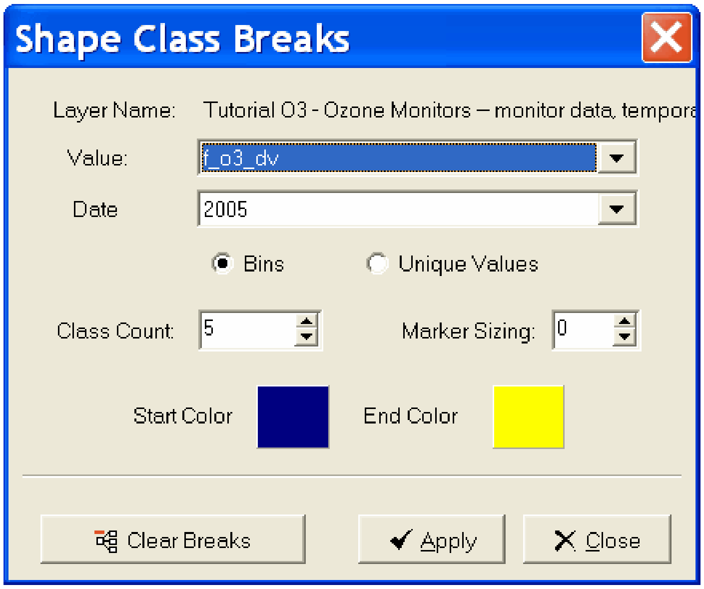

Zoom in further on the Eastern US using the **Zoom in** button on the Task Bar. This allows you to view the results more closely. A dashed line surrounds the area that you have chosen and should look something like the following:



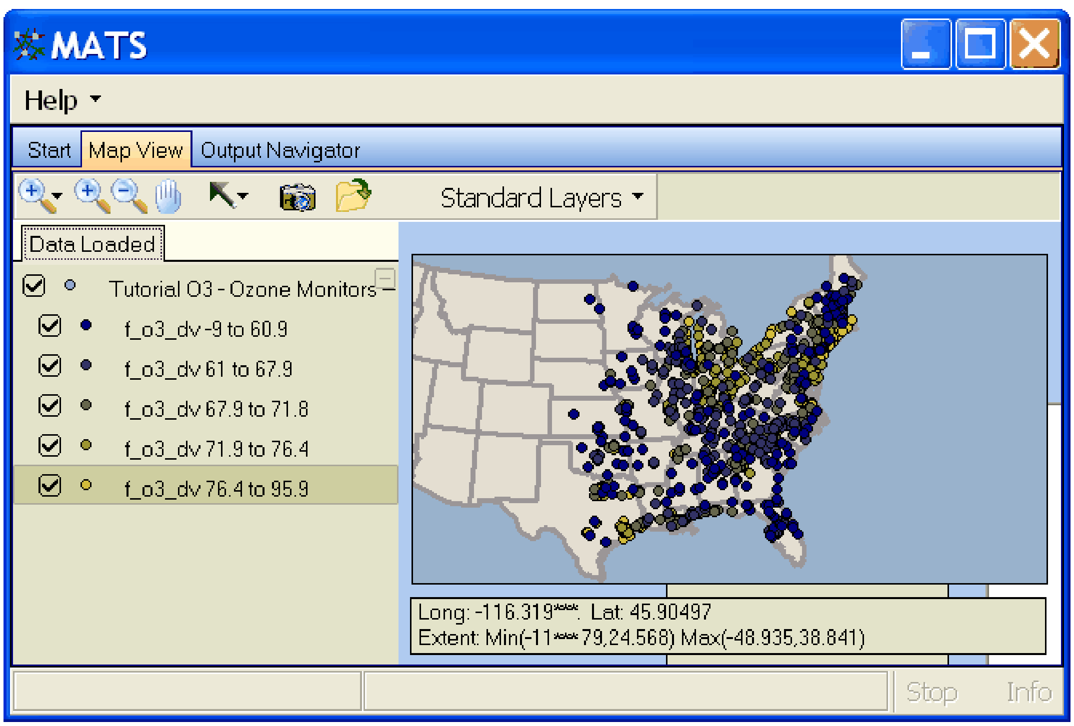
Right click on the "*Tutorial O3 - Ozone Monitors* -"layer in the panel on the left side of the window. Choose the **Plot Value** option.




This will bring up **Shape Class Breaks** window. In the **Value** drop-down list, choose the variable "*f_o3_dv*" -- this is forecasted ozone design value for 2015.




Click **Apply** and then click **Close**. This will bring you back to the **Map View** window.




Examine the other variables:

*b_o3_dv*: baseline ozone design value;

*rrf*: relative response factor used to forecast the ozone design value;

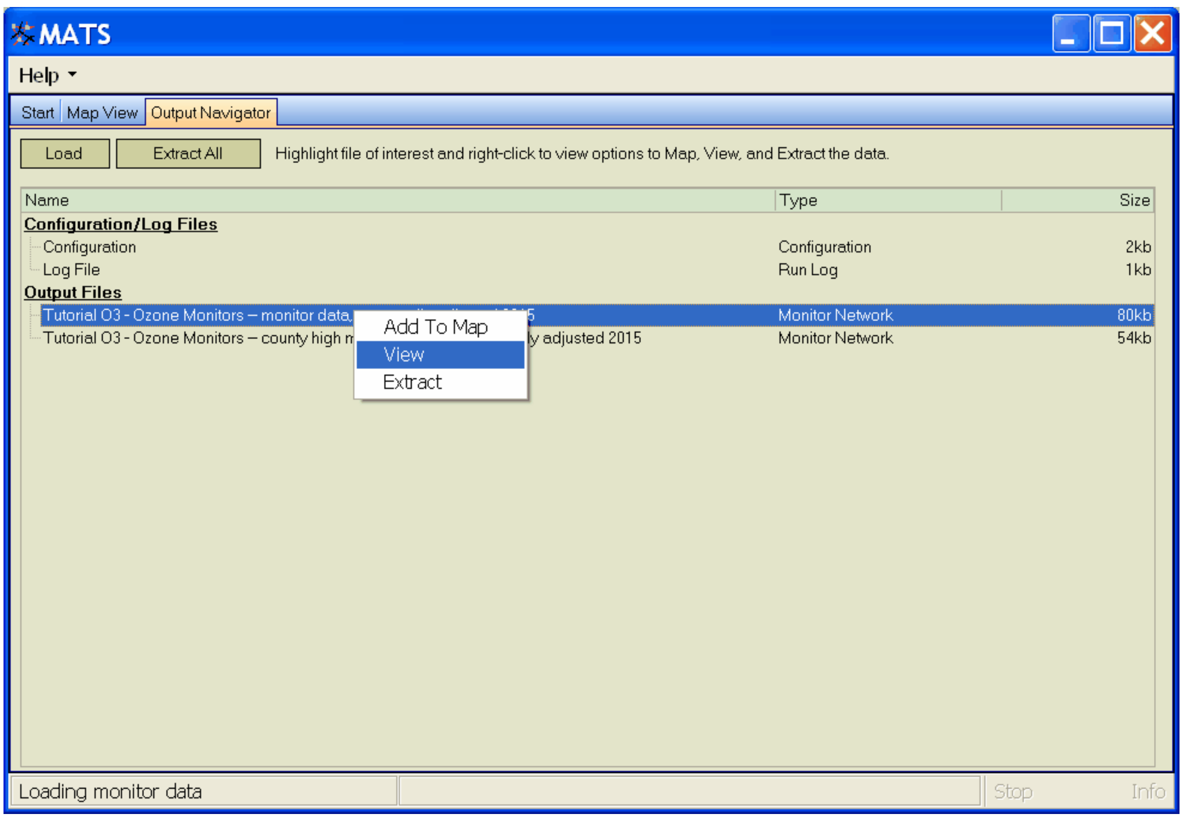
*ppb*: value of the threshold used;

*day:* number of days at or above the threshold.

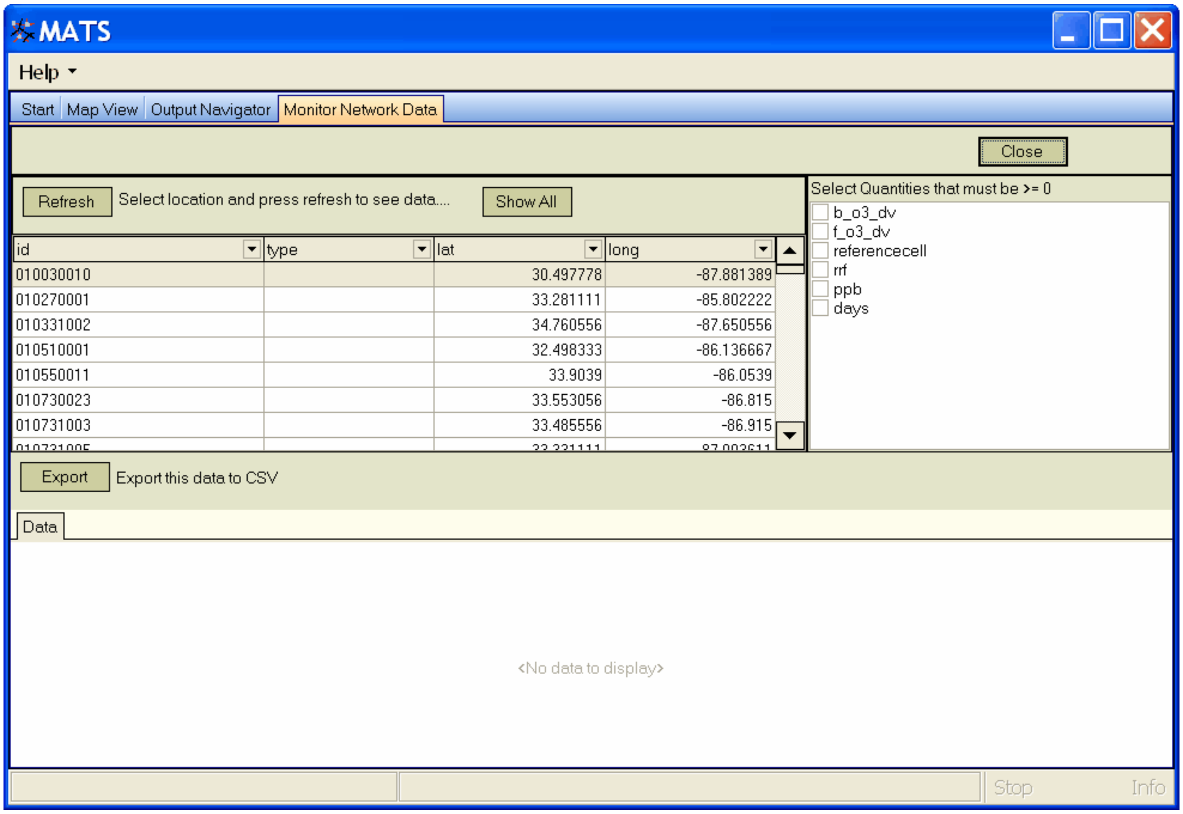
This is just a brief summary of the mapping possibilities available. For more details, there is a separate chapter on the Map View. The next step is to go to the **Output Navigator** to view the data in a table format.

## 6.8 Step 8. View & Export Results

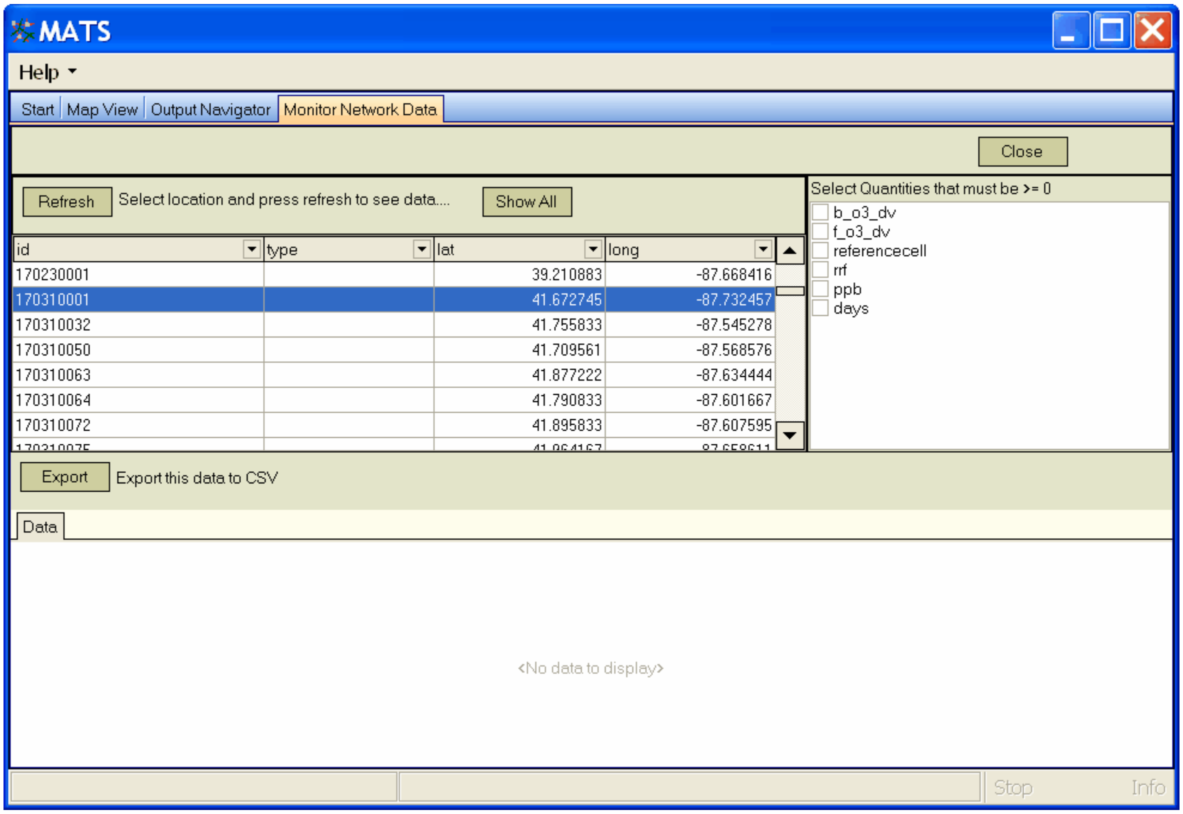
After mapping your results, click on the **Output Navigator** tab, so that you can then view the data in a table. Right-click on the file *Tutorial O3 - Ozone Monitors - monitor data temporally adjusted 2015*. This gives you three options: *Add to Map*, *View*, and *Extract*. Choose the *View* option.



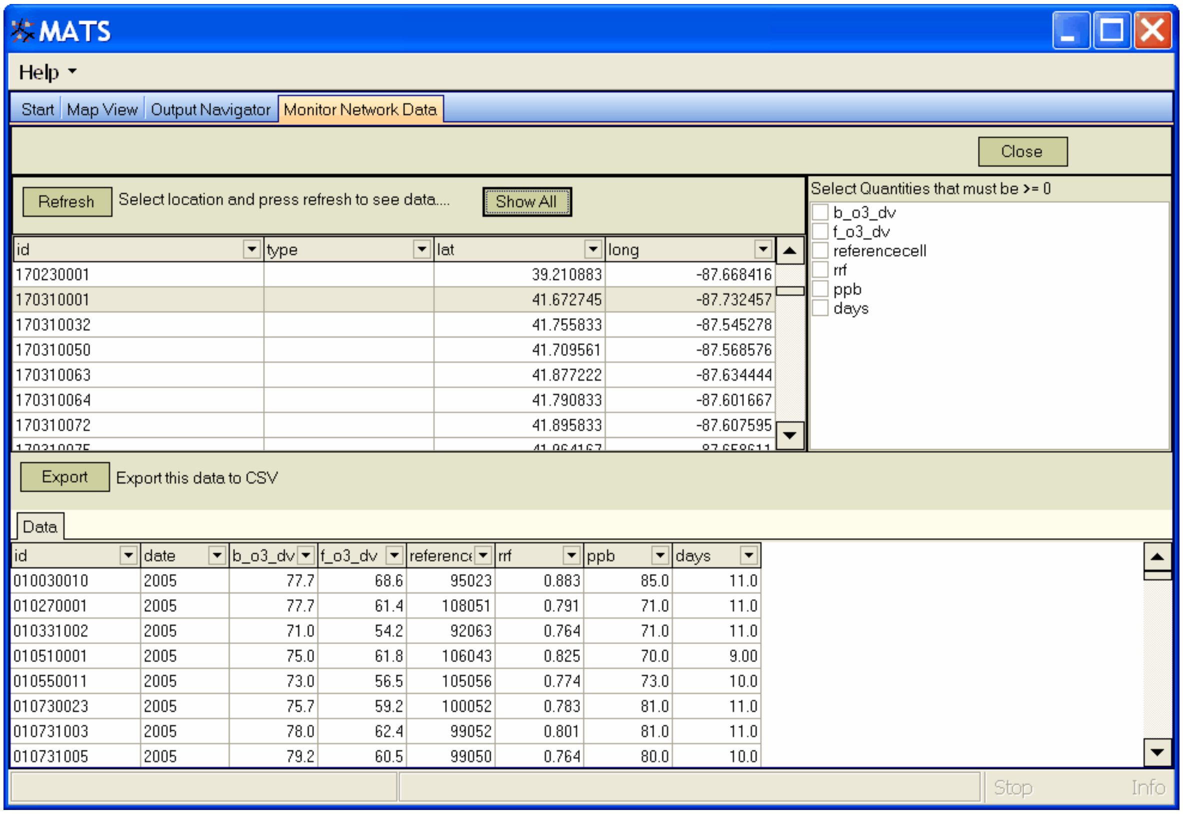

This will bring up a **Monitor Network Data** tab. The upper left panel allows you to view the ID and latitude and longitude of the monitors in your data -- at the right of this panel there is a scrollbar with which you can locate any particular monitor of interest.



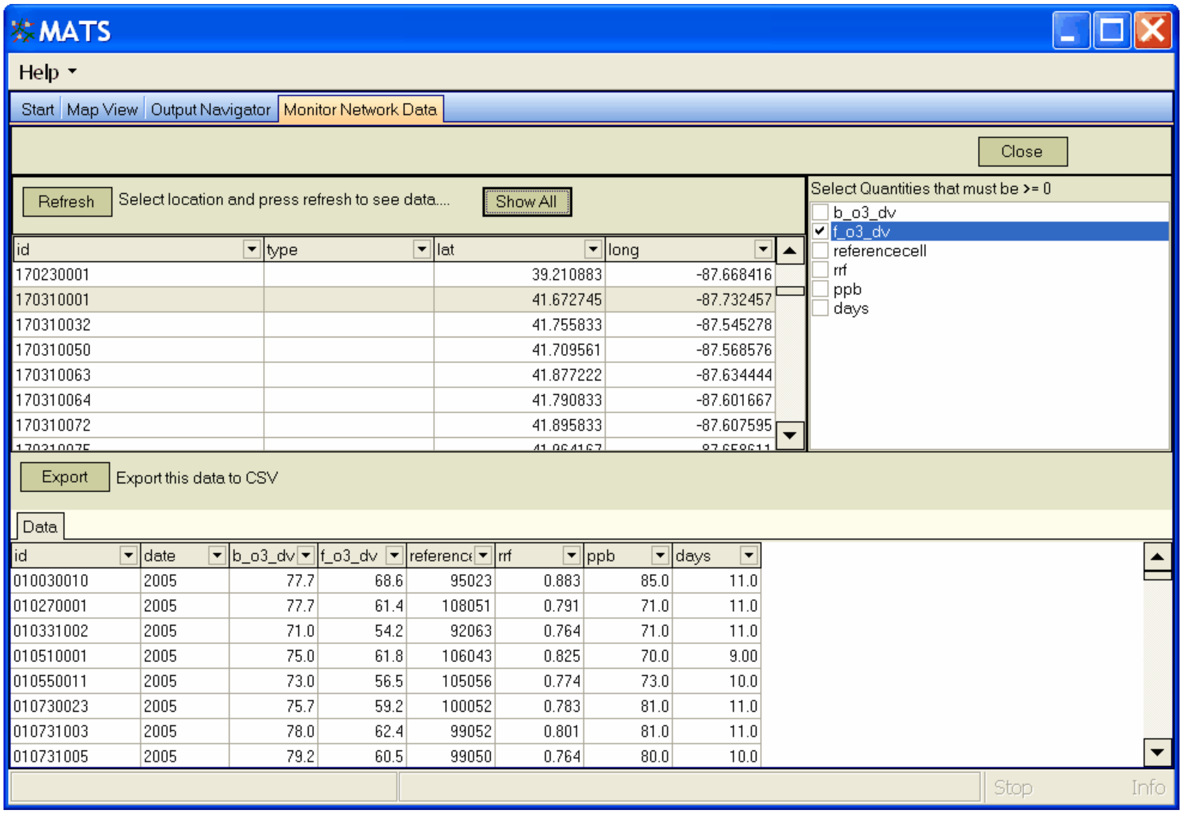

To view the data for a particular monitor -- in this example, monitor ID = "17031001" -- highlight this monitor and then click the **Refresh** button. MATS will then display the values for this monitor in the bottom panel.



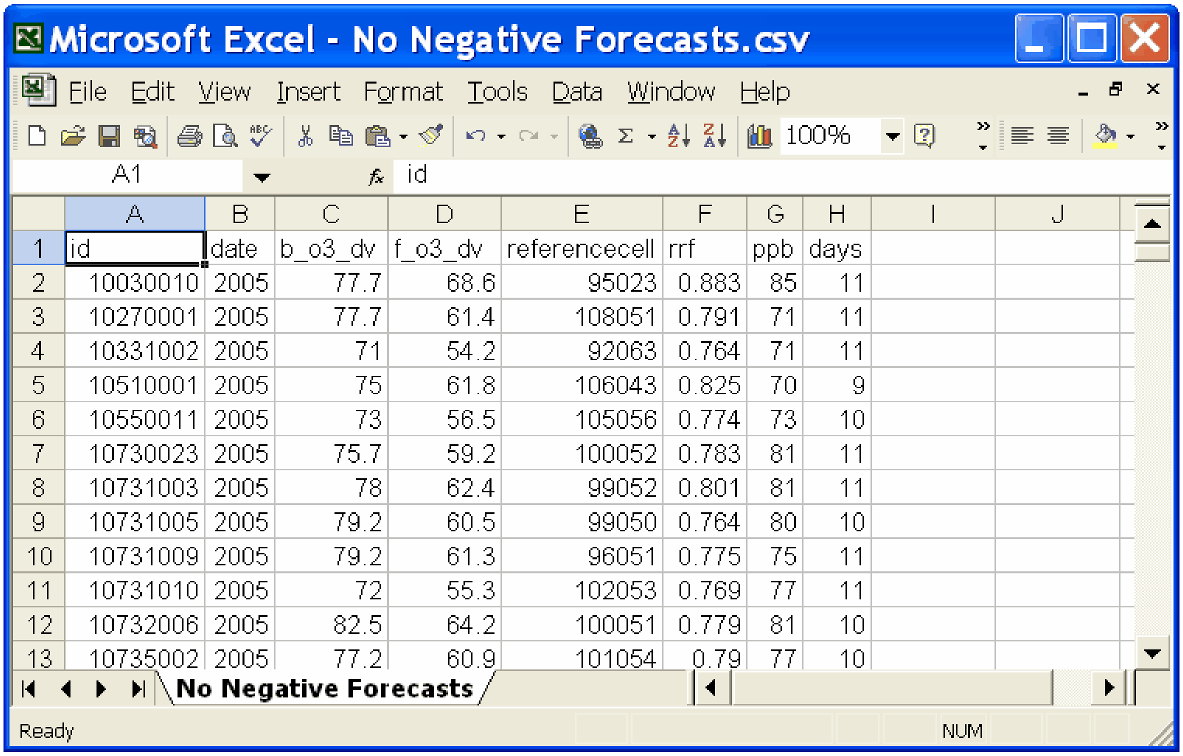

To view all of the data, click on the **Show All** button.




To eliminate missing values (denoted by negative numbers in the lower panel), check one or more boxes in the panel in the upper right of the window. For example, to eliminate any monitors that do not have a ozone design value forecast, check the forecasted ozone design value variable "*f_o3_dv*" and then click the **Show All** button.




Click the **Export** button and save the file as "*No Negative Forecasts*."  (It is unnecessary to add an extension.  MATS automatically saves the file as a CSV text file and adds a ".csv" extension to your file name.)  View the file in Excel.



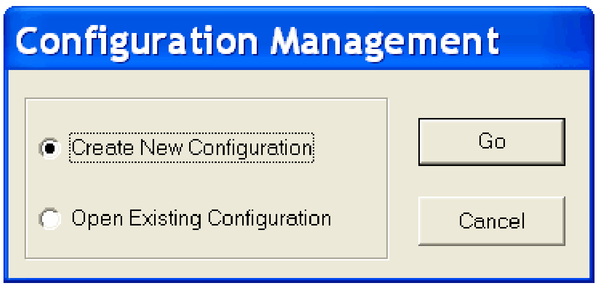

| id | date | b_o3_dv | f_o3_dv | referencecell | rrf | ppb | days |
|---|---|---|---|---|---|---|---|
| 10030010 | 2005 | 77.7 | 68.6 | 95023 | 0.883 | 85 | 11 |
| 10270001 | 2005 | 77.7 | 61.4 | 108051 | 0.791 | 71 | 11 |
| 10331002 | 2005 | 71 | 54.2 | 92063 | 0.764 | 71 | 11 |
| 10510001 | 2005 | 75 | 61.8 | 106043 | 0.825 | 70 | 9 |
| 10550011 | 2005 | 73 | 56.5 | 105056 | 0.774 | 73 | 10 |
| 10730023 | 2005 | 75.7 | 59.2 | 100052 | 0.783 | 81 | 11 |
| 10731003 | 2005 | 78 | 62.4 | 99052 | 0.801 | 81 | 11 |
| 10731005 | 2005 | 79.2 | 60.5 | 99050 | 0.764 | 80 | 10 |
| 10731009 | 2005 | 79.2 | 61.3 | 96051 | 0.775 | 75 | 11 |
| 10731010 | 2005 | 72 | 55.3 | 102053 | 0.769 | 77 | 11 |
| 10732006 | 2005 | 82.5 | 64.2 | 100051 | 0.779 | 81 | 10 |
| 10735002 | 2005 | 77.2 | 60.9 | 101054 | 0.79 | 77 | 10 |

For additional details on generating ozone results, see the chapter on Ozone Analysis: Details. For additional details on viewing data, see the View Data section in chapter on the Output Navigator

# 7 Ozone Analysis: Details

MATS can forecast design values at ozone monitor locations -- these forecasts are referred to as *Point Estimates*. MATS can also use a variety of approaches to calculate design values for a *Spatial Field*. A *Spatial Field* refers to a set of values comprising calculations for each grid cell in a modeling domain from Eulerian grid models such as CMAQ and CAMx.

The set of choices involved in calculating either *Point Estimates* or a *Spatial Field* can be fairly involved, so MATS keeps track of these choices using a Configuration. When you begin the process of generating ozone estimates, MATS provides an option to start a new Configuration or to open an existing Configuration.



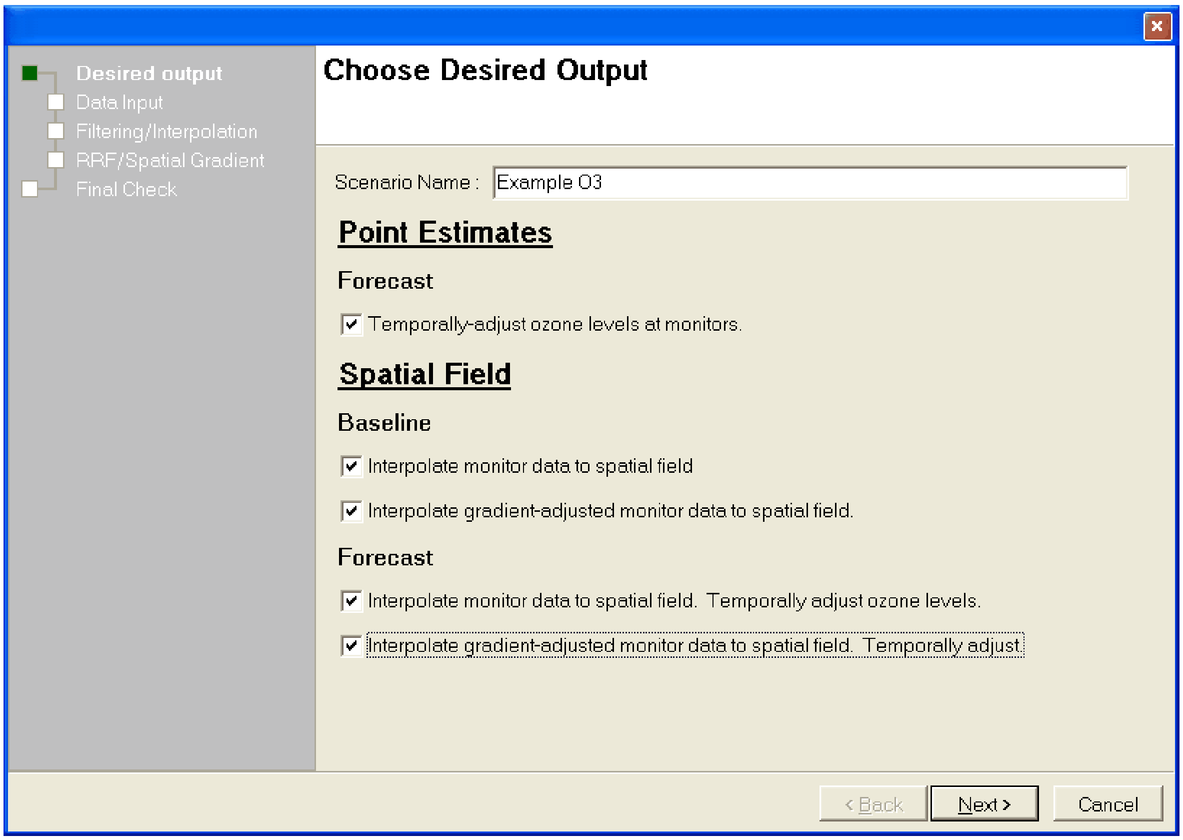

Select your option and then click **Go**.

MATS will then step you through a series of windows with choices for your analysis.

- Choose Desired Output**.** Choose whether you want Point Estimates, estimates for a Spatial Field, or both.
- Data Input**.** Specify the air quality modeling and ambient monitoring data that you want to use. Specify which model grid cells will be used when calculating RRFs at monitor locations.
- Filtering Interpolation. Choose the years of monitoring data. Identify valid monitors. Define the interpolation approach to be used (when calculating a Spatial Field).
- RRF and Spatial Gradient**.** Specify the daily ozone values that will be used in the calculation of RRFs and Spatial Gradients.
- Final Check. Verify the selections that you have made

## 7.1 Choose Desired Output

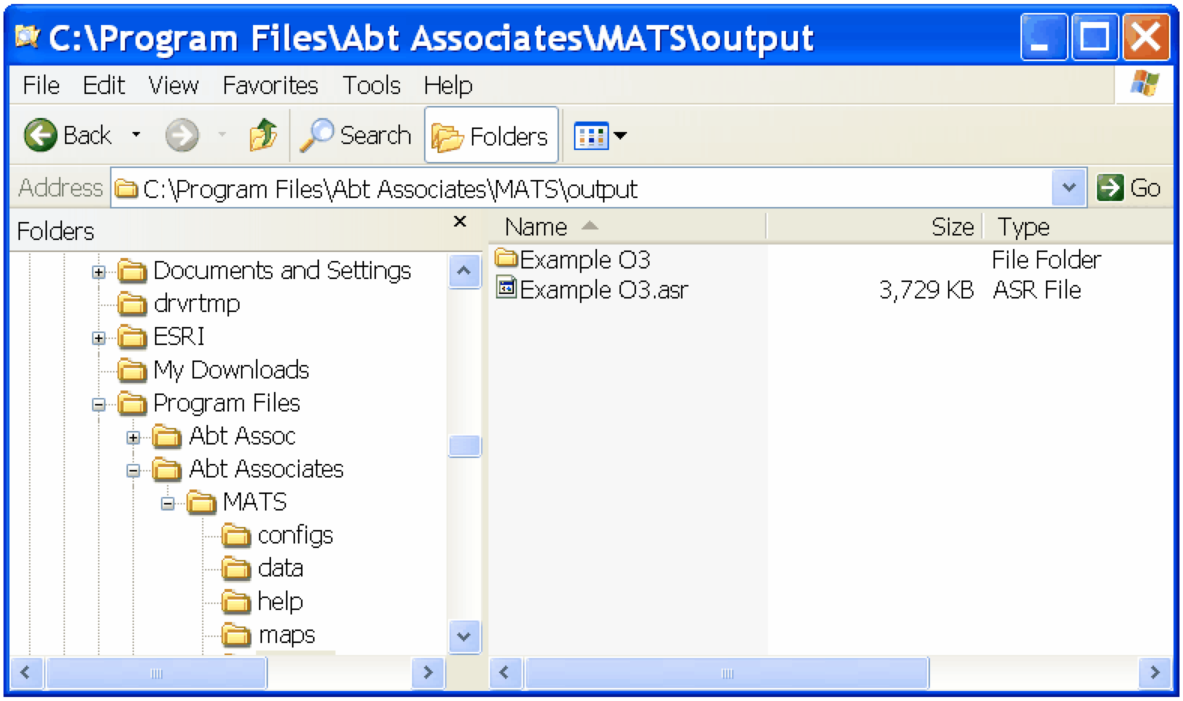
MATS lets you choose to generate Point Estimates, which refer to forecasts made at fixed locations, such as monitors. MATS can also generate Spatial Fields, which refer to air pollution estimates made at the center of each grid cell in a specified model domain. (For example if the model domain has 20 columns and 30 rows, then there are 600 grid cells for which MATS can generate estimates.) The Spatial Field estimates can be baseline estimates or forecasts, generated with or without a gradient adjustment.



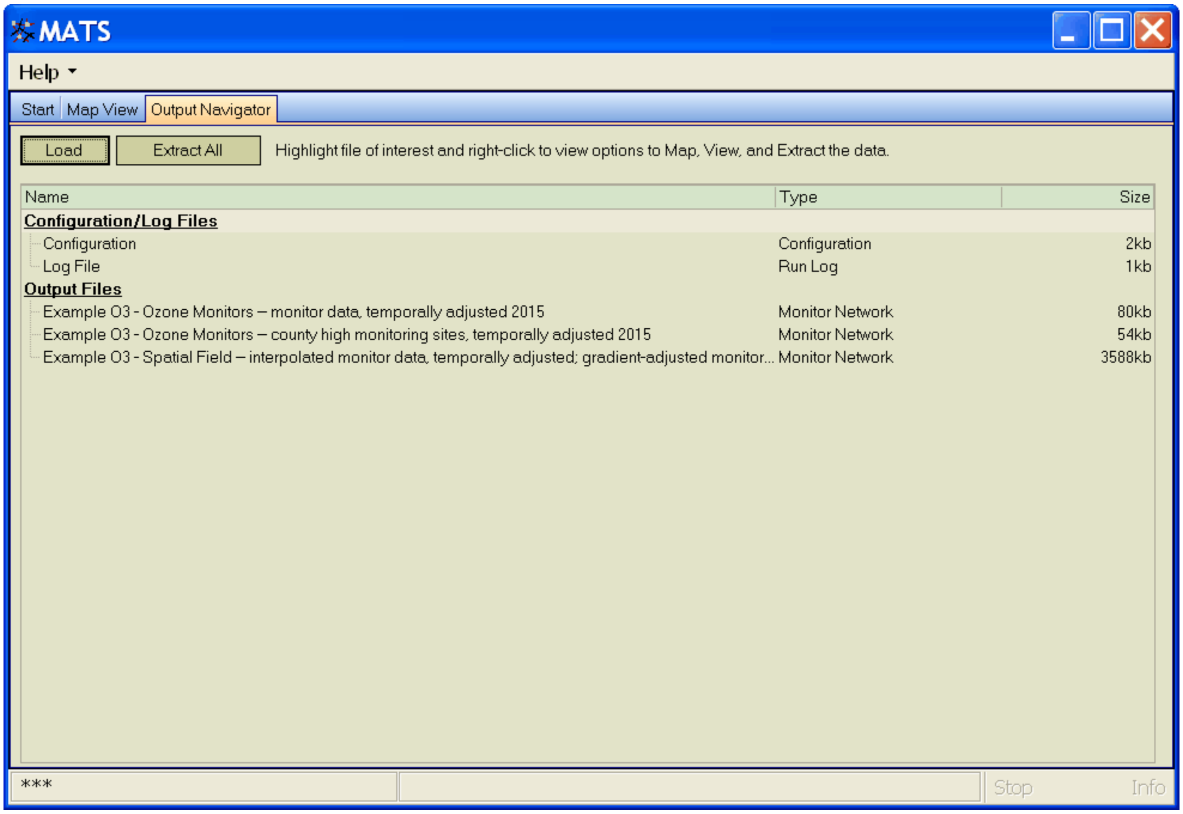

### 7.1.1 Scenario Name

The Scenario Name allows you to uniquely identify each analysis that you conduct. It is used in several ways.

- **Results file name**. The results file is given the **Scenario Name** (e.g., *Tutorial O3.asr*). Note that the extension (.ASR) is specifically designated just for MATS and can only be used by MATS.
- **Organize output**. In the Output folder, MATS will generate a folder using the Scenario Name. MATS will use this folder as a default location for files generated with this Scenario Name.

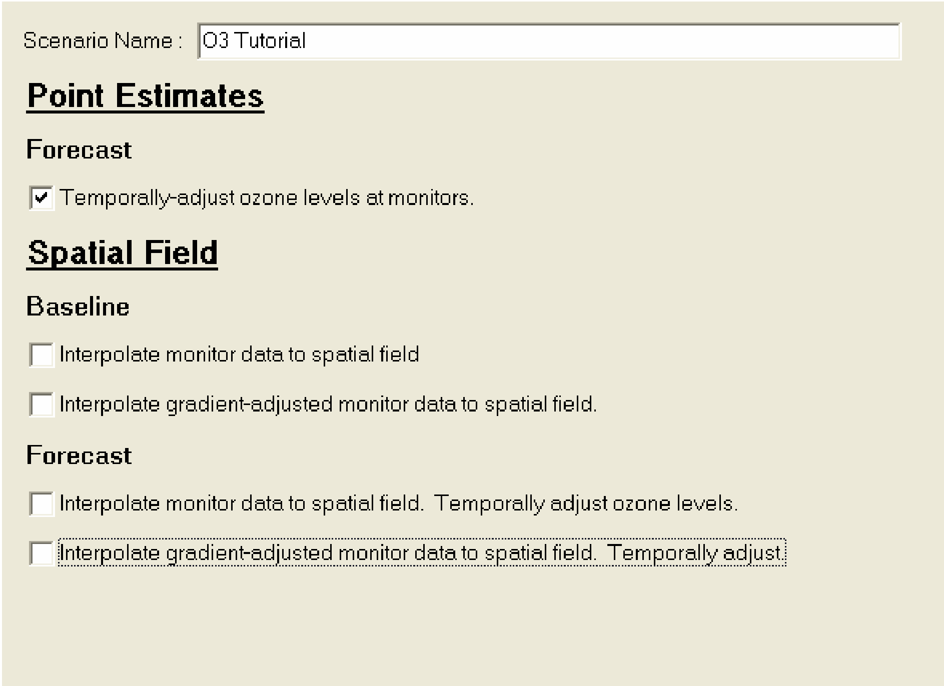



- **Output file names**. The output files generated will begin with the Scenario Name.




### 7.1.2 Point Estimates

The calculation of **Point Estimates**, or future-year ozone levels at monitors, has several steps (the process is laid out in more detail in Sections 3 and 4 of the EPA modeling guidance). The first step is to calculate the baseline value as a function of up to three design values. The second step is to use model data to temporal adjust the baseline value.




#### 7.1.2.1 Baseline Ozone

The baseline ozone design value is the simple average of design values, where the average carries one significant figure to the right of the decimal point. Generally, one should select design value years that match the modeling data being used. The EPA modeling guidance recommends using an average of the 3 design values periods which straddle the emissions base year. For example, if the modeled emissions base year is 2002, then design values from 2000-2002, 2001-2003, and 2002-2004 would be averaged. An average of design values is, in effect, a weighted average of annual averages -- 2002 is "weighted" three times, 2001 and 2003 are weighted twice, and 2000 and 2004 are weighted once. This creates a 5-year weighted average design value which is used to project future air quality levels.

The default design value years in MATS are the periods 2000-2004. This assumes a model base year of 2002. If the base year is not 2002, then the start and end design value period should be adjusted.

#### 7.1.2.2 Temporally-Adjust Baseline Ozone

The first step in temporally adjusting baseline ozone involves identifying the model grid cells near the monitor site. Next, MATS calculates the average of daily 8-hour average maximum model values for both the baseline and future-year model runs, and then takes the ratio of the two to calculate the RRF. Finally, MATS calculates the future-year design value by multiplying the RRF with the baseline design value measured at the monitor.

The equation for temporally adjusting baseline ozone is as follows:

$$Monitor_{i,\ future} = Monitor_i \cdot RRF_i$$

where:

$Monitor_{i,\ future}$ = future-year ozone design value at monitor site i, measured in parts per billion (ppb)

$Monitor_i$ = baseline ozone design value at monitor site i, measured in ppb

$RRF_i$ = relative response factor at monitor site i. The RRF is the ratio of the future 8-hour daily maximum concentration predicted near a monitor (averaged over multiple days) to the baseline 8-hour daily maximum concentration predicted near the monitor (averaged over the same days).

NOTE: The calculation of the RRF involves a number of assumptions that are specified in the RRF and Spatial Gradient window.

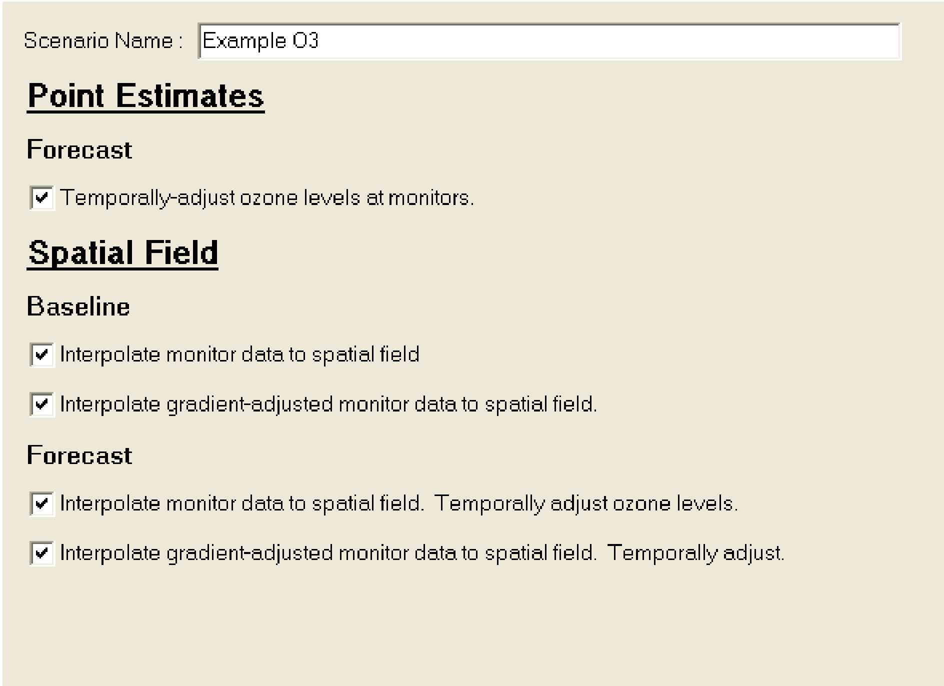
### 7.1.3 Spatial Field

A Spatial Field refers to air pollution estimates made at the center of each grid cell in a specified model domain. For example, MATS might calculate ozone design values for each grid cell in a modeling domain.

MATS calculates four types of ozone-related Spatial Fields:

- Baseline - interpolate monitor data to spatial field. This is an interpolation of baseline monitor values at each grid cell. MATS identifies the "neighbor" monitors for each grid cell and then calculates an inverse-distance-weighted average of the monitor values at each grid cell.
- Baseline - interpolate gradient-adjusted monitor data to spatial field. This is an interpolation of model-adjusted baseline monitor values at each grid cell. MATS identifies the "neighbor" monitors for each grid cell, it adjusts the monitor values to account for the modeled spatial gradient, and then calculates an inverse-distance-weighted average of the monitor values.
- Forecast - interpolate monitor data to spatial field. Temporally Adjust. This is an interpolation of baseline monitor values at each grid cell that are then temporally adjusted to a future year. MATS calculates the **Baseline - interpolate monitor data to spatial field** and multiplies it with a RRF.
- Forecast - interpolate gradient-adjusted monitor data to spatial field. Temporally adjust. This is an interpolation of model-adjusted baseline monitor values at each grid cell that are then temporally adjusted to a future year. MATS calculates the **Baseline - interpolate gradient-adjusted monitor data to spatial field** and multiplies it with a RRF.

Details on the calculations are provided in the following sections.




#### 7.1.3.1 Baseline - interpolate monitor data to spatial field

To calculate baseline ozone design values for a spatial field, MATS starts with the baseline ozone levels at the monitor and interpolates them to the centroid of the spatial field. The basic form of the equation is as follows:

$$Gridcell_{E,\,baseline} = \sum_{i=1}^{n} Weight_i \cdot Monitor_i$$

where:

$Gridcell_{E,\ baseline}$ = baseline ozone concentration at unmonitored site E;

$Weight_i$ = inverse distance weight for monitor i;

$Monitor_i$ = baseline ozone concentration at monitor i.

#### 7.1.3.2 Baseline - interpolate gradient-adjusted monitor data to spatial field

Using modeling data for gradient scaling is fairly simple: MATS uses the model value for the grid cell of interest and the model values for the grid cells containing the monitors to be interpolated to the grid cell of interest. A general form of the equation is as follows:

$$Gridcell_{E,\,baseline} = \sum_{i=1}^{n} Weight_i \cdot Monitor_i \cdot Gradient\ Adjustment_{i,E}$$

where:

$Gridcell_{E,\,baseline}$ = baseline ozone concentration at unmonitored site E;

$Weight_i$ = inverse distance weight for monitor i;

$Monitor_i$ = baseline ozone concentration at monitor i;

$Gradient\ Adjustment_{i,\,E}$ = gradient adjustment from monitor i to unmonitored site E.

There are a variety of approaches that might be used to calculate the gradient adjustment. As a default, MATS averages the five highest daily 8-hour values. The equation can then be rewritten as follows:

$$Gridcell_{E,\,baseline} = \sum_{i=1}^{n} Weight_i \cdot Monitor_i \cdot \frac{Model_{E,\,baseline}}{Model_{i,\,baseline}}$$

where:

$Model_{E,\,baseline}$ = baseline scenario, average of five highest daily 8-hour values at site E;

$Model_{i,\,baseline}$ = baseline scenario, average of five highest daily 8-hour values at monitor site i.

#### 7.1.3.3 Forecast - interpolate monitor data to spatial field. Temporally-adjust ozone levels

To get the forecasted design value for each grid-cell in the spatial field, MATS multiplies the Baseline - interpolate monitor data to spatial field for each grid-cell with the RRF calculated for that grid-cell. The equation is as follows:

$$Gridcell_{E,\,future} = Gridcell_{E,\,baseline} \cdot RRF_E$$

where:

$Gridcell_{E,\,baseline}$ = baseline ozone concentration at unmonitored site E;

$Weight_i$ = inverse distance weight for monitor i;

$Monitor_i$ = baseline ozone concentration at monitor i.

NOTE: The RRF is calculated using the same approach as for Point Estimates (except when a backstop threshold minimum is set [see section 7.4.1.6]).

#### 7.1.3.4 Forecast - interpolate gradient-adjusted monitor data to spatial field. Temporally-adjust ozone levels

To get the forecasted design value for each grid-cell in the spatial field *with* a gradient adjustment, MATS multiplies the Baseline - interpolate gradient-adjusted monitor data to spatial field for each grid-cell with the RRF calculated for that grid cell. The equation is as follows:

$$Gridcell_{E,\,future} = Gridcell_{E,\,baseline} \cdot RRF_E$$

where:

$Gridcell_{E,\ baseline}$ = baseline ozone concentration at unmonitored site E;

$Weight_i$ = inverse distance weight for monitor i;

$Monitor_i$ = baseline ozone concentration at monitor i.

NOTE: The RRF is calculated using the same approach as for Point Estimates (except when a backstop threshold minimum is set [see section 7.4.1.6]).

### 7.1.4 Output Variable Description

MATS generates up to three output files:

- Ozone forecasts for all monitors. The name of this file is "Ozone Monitors -- monitor data, temporally adjusted *yyyy*.csv" with the Scenario Name appended at the beginning and the forecast year is inserted at the end (e.g., "Example O3 -- Ozone Monitors -- county high monitoring sites, temporally adjusted 2015.csv").
- Ozone forecasts for the highest monitor in each county. The name of this file is "Ozone Monitors -- county high monitoring sites, temporally adjusted *yyyy*.csv" with the Scenario Name appended at the beginning and the forecast year inserted at the end.
- Spatial field forecasts. The name of this file is "Spatial Field -- interpolated monitor data, temporally adjusted; gradient-adjusted monitor data, temporally adjusted *yyyy*.csv" with the Scenario Name appended at the beginning and the forecast year inserted at the end.

The following sub-sections describe the variables in each file.

#### 7.1.4.1 Ozone Monitors -- monitor data, temporally adjusted 2015.csv

An example of this output file is as follows (with variable definitions in the table below):

**Example O3 - Ozone Monitors -- monitor data, temporally adjusted 2015.csv**

| Year<br>_id | _type | lat | long | date | b_o3_DV | f_o3_DV | reference cell | rrf | ppb | days | _state_name | _county_name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10030010 | | 30.4978 | -87.8814 | 2005 | 77.7 | 68.6 | 95023 | 0.883 | 85 | 11 | Alabama | Baldwin |
| 10270001 | | 33.2811 | -85.8022 | 2005 | 77.7 | 61.4 | 108051 | 0.791 | 71 | 11 | Alabama | Clay |
| 10331002 | | 34.7606 | -87.6506 | 2005 | 71 | 54.2 | 92063 | 0.764 | 71 | 11 | Alabama | Colbert |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10510001 | 32.4983 | -86.1367 | 2005 | 75 | 61.8 | 106043 | 0.825 | 70 | 9 | Alabama | Elmore |
| 10550011 | 33.9039 | -86.0539 | 2005 | 73 | 56.5 | 105056 | 0.774 | 73 | 10 | Alabama | Etowah |

| Variable | Description |
|---|---|
| _id | The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.) |
| _type | Leave blank |
| lat | Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| long | Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| date | The date represents the last year of the chosen design value periods (e.g., if a 5 year period is chosen, 2005 represents the 2001-2005 period ). |
| b_o3_DV | Baseline design value |
| f_o3_DV | Forecasted (future year) design value |
| referencecell | Identifier of the closest model grid cell centroid to the monitor. |
| rrf | Relative response factor is the ratio of the future year modeled concentration predicted near a monitor (averaged over multiple days) to the base year modeled concentration predicted near the monitor (averaged over the same days). |
| ppb | Threshold value (measured in parts per billion) used in the rrf calculation |
| days | Number of days at or above the threshold value. |
| _state_name | State name. (This is a character variable.) |
| _county_name | County name. (This is a character variable.) |

### 7.1.4.2 Ozone Monitors -- county high monitoring sites, temporally adjusted 2015.csv

An example of this output file is as follows (with variable definitions in the table below):

Example O3 - Ozone Monitors -- county high monitoring sites, temporally adjusted 2015.csv

| Year<br>_id | _type | lat | long | date | b_o3_DV | f_o3_DV | referencecell | rrf | ppb | days | _state_name | _county_name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10030010 | | 30.4978 | -87.8814 | 2005 | 77.7 | 68.6 | 95023 | 0.883 | 85 | 11 | Alabama | Baldwin |
| 10270001 | | 33.2811 | -85.8022 | 2005 | 77.7 | 61.4 | 108051 | 0.791 | 71 | 11 | Alabama | Clay |
| 10331002 | | 34.7606 | -87.6506 | 2005 | 71 | 54.2 | 92063 | 0.764 | 71 | 11 | Alabama | Colbert |
| 10510001 | | 32.4983 | -86.1367 | 2005 | 75 | 61.8 | 106043 | 0.825 | 70 | 9 | Alabama | Elmore |
| 10550011 | | 33.9039 | -86.0539 | 2005 | 73 | 56.5 | 105056 | 0.774 | 73 | 10 | Alabama | Etowah |
| 10732006 | | 33.3864 | -86.8167 | 2005 | 82.5 | 64.2 | 100051 | 0.779 | 81 | 10 | Alabama | Jefferson |
| 10790002 | | 34.3428 | -87.3397 | 2005 | 75.2 | 58.7 | 95059 | 0.781 | 70 | 5 | Alabama | Lawrence |
| 10890014 | | 34.6908 | -86.5831 | 2005 | 79 | 63.4 | 100063 | 0.803 | 70 | 10 | Alabama | Madison |

| Variable | Description |
|---|---|
| _id | The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.) |
| _type | Leave blank |
| lat | Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| long | Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| date | The date represents the last year of the selected design value periods (e.g., if a 5 year period is selected, 2005 represents the 2001-2005 period ). |
| b_o3_DV | Baseline design value |
| f_o3_DV | Forecasted (future year) design value |
| referencecell | Identifier of the closest model grid cell centroid to the monitor. |
| rrf | Relative response factor is the ratio of the future year modeled concentration predicted near a monitor (averaged over multiple days) to the base year modeled concentration predicted near the monitor (averaged over the same days). |
| ppb | Threshold value (measured in parts per billion) used in the rrf calculation |
| days | Number of days at or above the threshold value. |
| _state_name | State name. (This is a character variable.) |
| _county_name | County name. (This is a character variable.) |

### 7.1.4.3 Spatial Field -- interpolated monitor data, temporally adjusted; gradient-adjusted monitor data, temporally adjusted 2015.csv

An example of this output file is as follows (with variable definitions in the table below):

Example O3 - Spatial Field -- interpolated monitor data, temporally adjusted; gradient-adjusted monitor data, temporally adjusted 2015.csv

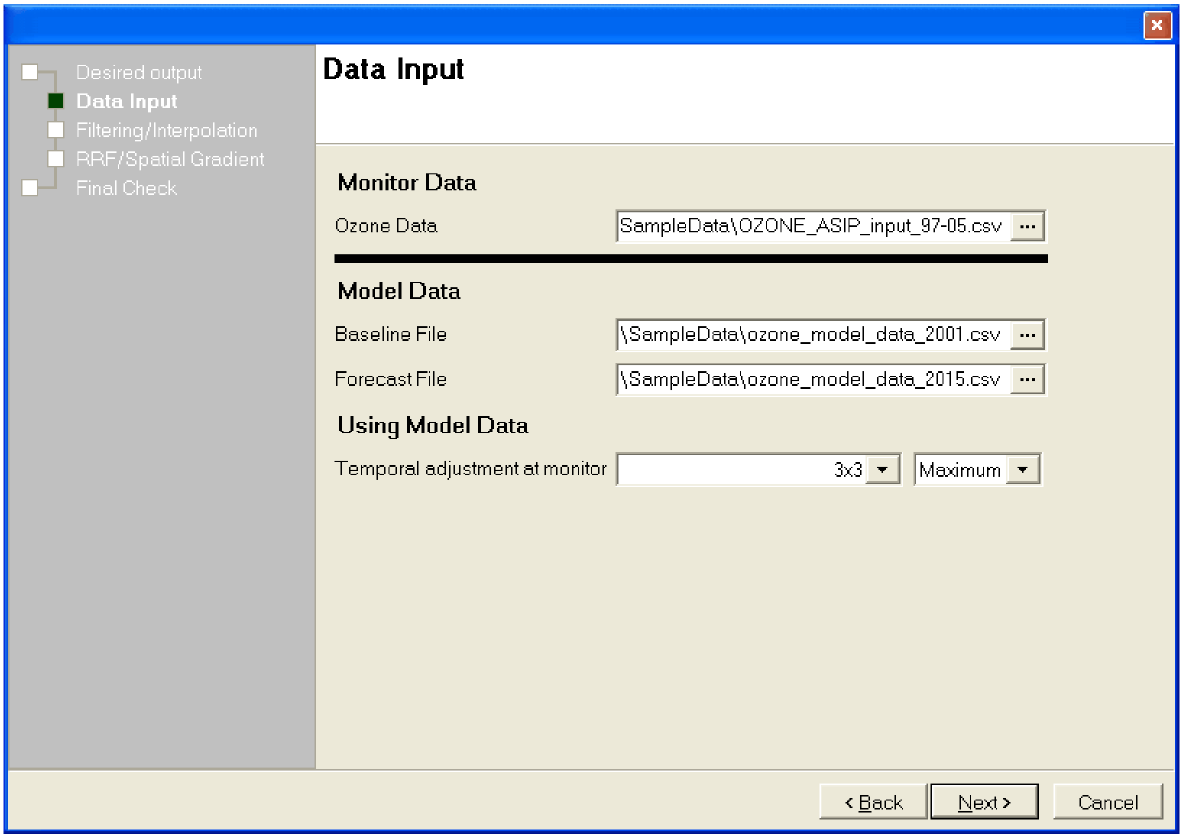
Year

| _id | _type | lat | long | date | ga_conc | i_b_o3 | i_f_o3 | i_b_ga_o3 | i_f_ga_o3 | ppb | days | referencecell | rrf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100001 | | 28.0638 | -87.4991 | 2005 | -13 | 79.2 | -9 | -8 | -9 | 70 | 0 | 100001 | -9 |
| 100002 | | 28.1698 | -87.4865 | 2005 | -13 | 79.2 | -9 | -8 | -9 | 70 | 0 | 100002 | -9 |
| 100003 | | 28.2759 | -87.4738 | 2005 | -13 | 79.2 | -9 | -8 | -9 | 70 | 0 | 100003 | -9 |
| 100004 | | 28.3820 | -87.4611 | 2005 | 71.6 | 79.1 | -9 | 69.9 | -9 | 70 | 4 | 100004 | -9 |
| 100005 | | 28.4881 | -87.4484 | 2005 | 72 | 79.1 | 70 | 70.2 | 62.1 | 70 | 5 | 100005 | 0.885 |
| 100006 | | 28.5943 | -87.4356 | 2005 | 72.2 | 79.2 | 69.9 | 70.4 | 62.1 | 70 | 5 | 100006 | 0.883 |
| 100007 | | 28.7005 | -87.4229 | 2005 | 72.3 | 79.2 | 69.8 | 70.4 | 62 | 70 | 5 | 100007 | 0.882 |
| 100008 | | 28.8068 | -87.4100 | 2005 | 72.5 | 78.9 | 69.1 | 70.5 | 61.8 | 70 | 5 | 100008 | 0.877 |

| Variable | Description |
|---|---|
| _id | The ID is a unique name for each monitor in a particular location. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.) |
| _type | Leave blank |
| lat | Latitude in decimal degrees of the center of each grid cell. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| long | Longitude in decimal degrees of the center of each grid cell. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| date | The date represents the last year of the selected design value periods (e.g., if a 5 year period is selected, 2005 represents the 2001-2005 period ). |
| ga_conc | Modeled concentration (ppb) used for gradient adjustment (average of "start value" and "end value") |
| i_b_o3 | Interpolated (to spatial field) baseline concentration (ppb). |
| i_f_o3 | Interpolated (to spatial field) future year concentration (ppb). |
| i_b_ga_o3 | Interpolated (to spatial field) gradient adjusted baseline concentration (ppb). |
| i_f_ga_o3 | Interpolated (to spatial field) gradient adjusted future year concentration (ppb). |
| ppb | Threshold value (measured in parts per billion) used in the rrf calculation |
| days | Number of days at or above the threshold value. |
| referencecell | Identifier of the grid cell. (In the case of spatial fields, this is identical to the _ID variable.) |
| rrf | Relative response factor is the ratio of the future year modeled concentration predicted near a monitor (averaged over multiple days) to the base year modeled concentration predicted near the monitor (averaged over the same days). |

## 7.2 Data Input

In the Data Input window, you need to specify the air quality modeling and ambient monitoring data that you want to use. In addition, you need to specify which model grid cells will be used when calculating RRFs at monitor locations.




### 7.2.1 Monitor Data

Monitor data should be in the form of a simple text file. The first row specifies the frequency of the data (*e.g.*, day). The second row presents comma-separated variable names. The third row begins the data values. Below is an example of the monitor data file format and descriptions of the variables in the file.

**Format of Ozone Monitor Data**

```
DesignValue
_ID,_TYPE,LAT,LONG,POC,DVYEAR,O3,_STATE_NAME,_COUNTY_NAME
"010030010", ,30.497778,-87.881389,1,1999,-9,"Alabama","Baldwin"
"010030010", ,30.497778,-87.881389,1,2000,-9,"Alabama","Baldwin"
"010030010", ,30.497778,-87.881389,1,2001,-9,"Alabama","Baldwin"
"010030010", ,30.497778,-87.881389,1,2002,82,"Alabama","Baldwin"
"010030010", ,30.497778,-87.881389,1,2003,76,"Alabama","Baldwin"
"010030010", ,30.497778,-87.881389,1,2004,76,"Alabama","Baldwin"
"010030010", ,30.497778,-87.881389,1,2005,77,"Alabama","Baldwin"
"010270001", ,33.281111,-85.802222,1,1999,88,"Alabama","Clay"
```

**Ozone Monitor Data Variable Descriptions**

| Variable | Description |
|---|---|
| _ID | The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.) |
| _TYPE | Leave this blank. |
| LAT | Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| LONG | Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| DATE | The time period of the monitor observation. As a convention, the date represents the last year of the three-year design value period (e.g., 2001 represents the 1999-2001 design value). |
| O3 | Observed monitor value. Note that missing values are represented by a minus nine (-9). |
| _STATE_NAME | State name. (This is a character variable.) |
| _COUNTY_NAME | County name. (This is a character variable.) |

NOTE: Character variables have names that begin with an underscore (*i.e.*, "_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

### 7.2.2 Model Data

The model data should be in the form of a simple text file. The first row specifies the frequency of the data (*e.g.*, day). The second row presents comma-separated variable names. The third row begins the data values. The ozone model data should be the daily 8-hour average maximum concentration in each grid cell. Below is an example of the model data file format and descriptions of the variables in the file.

**Format of Ozone Model Data**

```
Day
  _ID,_TYPE,   LAT ,  LONG  ,    DATE  , O3
 1001,"",28.471949, -99.489582,20150501,45.2324
 1001,"",28.471949, -99.489582,20150502,42.6581
 1001,"",28.471949, -99.489582,20150503,47.4534
 1001,"",28.471949, -99.489582,20150504,51.9678
 1001,"",28.471949, -99.489582,20150505,53.6575
 1001,"",28.471949, -99.489582,20150506,47.1936
 1001,"",28.471949, -99.489582,20150507,48.3454
 1001,"",28.471949, -99.489582,20150508,49.5464
 1001,"",28.471949, -99.489582,20150509,34.3454
```

**Ozone Model Data Variable Descriptions**

**Variable** **Description**

| | |
|---|---|
| _ID | The ID is a unique number for each model grid cell in the air quality model domain. It is generally based on the column and row identifiers from the air quality modeling domain. The default convention is to calculate the ID by multiplying the column identifier by one thousand (1000) and adding the row identifier. (This is a character variable.) |
| _TYPE | Leave this blank. |
| LAT | Latitude in decimal degrees of the center of each grid cell. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| LONG | Longitude in decimal degrees of the center of each grid cell. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| DATE | The time of the monitor observation. The day is represented in the yyyymmdd format |
| O3 | Modeled ozone concentration (8-hour average daily maximum). |

NOTE: Character variables have names that begin with an underscore (*i.e.*, "_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

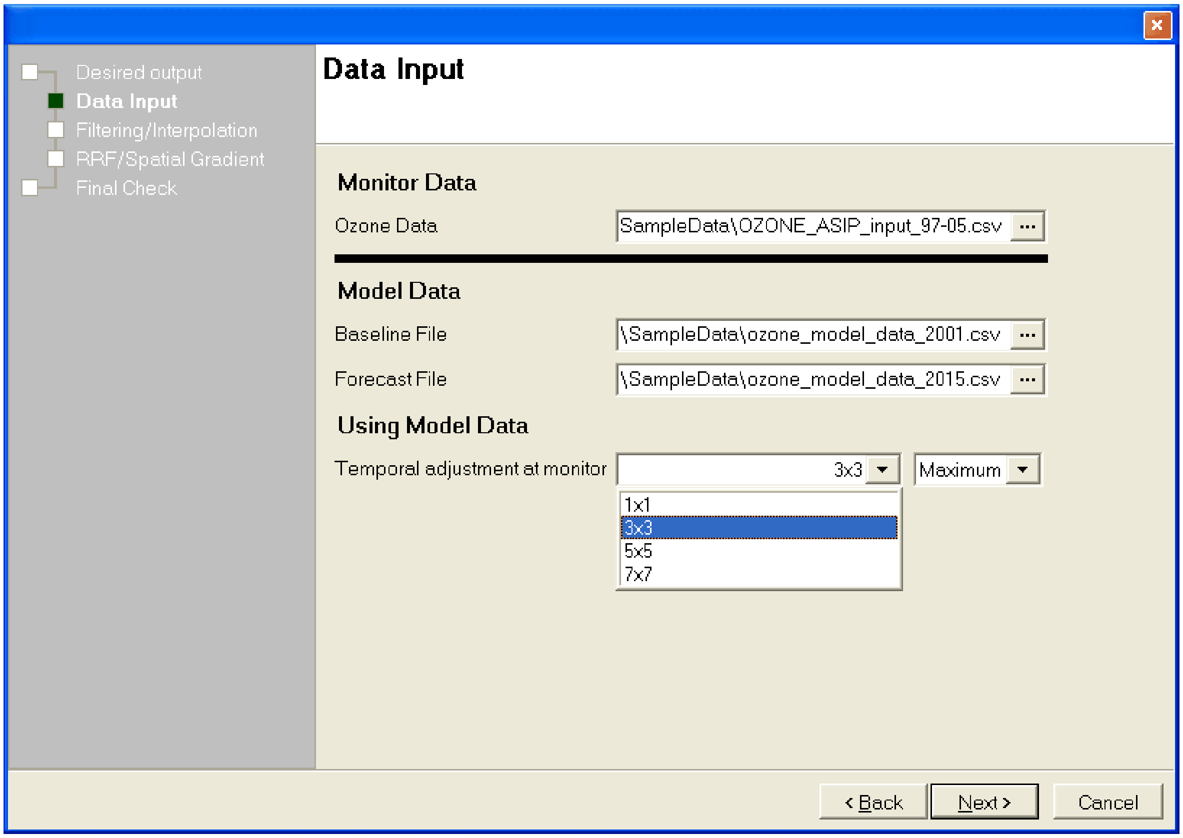
#### 7.2.2.1 EPA Default Model Data

The example model output dataset in MATS comprises daily 8-hour average maximums from May-September at 12km resolution. The baseline year for the modeling is 2001 and the future year is 2015.

### 7.2.3 Using Model Data

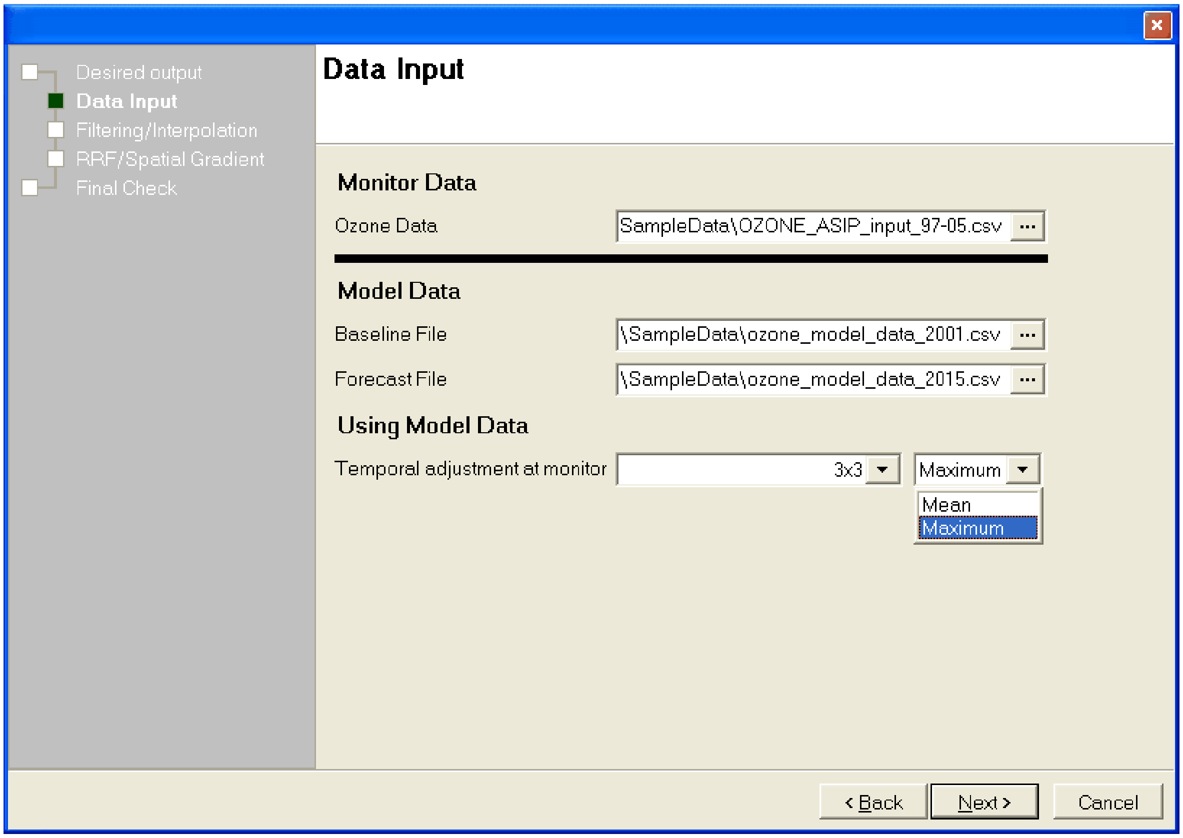
The RRF for a monitor is calculated from "nearby" model grid cells. For purposes of this calculation, a monitor is assumed to be at the center of the cell in which it is located, and this cell is at the center of an array of “nearby” cells.

The number of cells considered “nearby” a monitor is a function of the size of the grid cells used in the modeling. In the example case of a 12 km grid, EPA uses as a default 3x3 array of grid cells (see section 3.2 of the EPA modeling guidance for more details).




With the array size determined, MATS gives you two options for how you might use the modeling data.

- **Maximum**. For each day of modeling data, MATS will identify the highest 8-hour daily maximum among the grid cells in the chosen array. In the case of a 3x3 array, MATS will identify the highest daily 8-hour average maximum from among the nine “nearby” grid cells for each day and for each monitor site.
- **Mean**. For each day of modeling data, MATS will average the 8-hour daily values for the grid cells in the chosen array. In the case of a 3x3 array, MATS will average nine values.




The default choice for the ozone analysis in MATS is to use the **maximum** value among the array of grid cells, when calculating temporally-adjusted ozone levels at each monitor.

NOTE: For monitors on the border of a modeling domain -- where it may not be possible to have a full set of neighbors -- MATS uses the available modeling data.

#### 7.2.3.1 Nearby Monitor Calculation - Example 1

**Given**:

(1) Four primary days have been simulated using baseline and future emissions.

(2) The horizontal dimensions for each surface grid cell are 12 km x 12 km.

(3) In each of the 9 grid cells "near" a monitor site I, the maximum daily predicted future concentrations are 87.2, 82.4, 77.5, and 81.1 ppb.

(4) In each of the 9 grid cells "near" a monitor site I, the maximum daily predicted baseline 8-hour daily maximum ozone concentrations are 98.3, 100.2, 91.6, and 90.7 ppb.

**Find**:

The site-specific relative response factor for monitoring site I, (RRF)I

**Solution**:

(1) For each day and for both baseline and future emissions, identify the 8-hour daily maximum concentration predicted near the monitor. Since the grid cells are 12 km, a 3 x 3 array of cells is considered "nearby" (see Table 3.2).

(2) Compute the mean 8-hour daily maximum concentration for (a) future and (b) baseline emissions. Using the information from above, (a) (Mean 8-hr daily max.)future = (87.2 + 82.4 + 77.5 + 81.1)/4 = 82.1 ppb and (b) (Mean 8-hr daily max.)baseline = (98.3 + 100.2 + 91.6 + 90.7)/4 = 95.2 ppb

(3) The relative response factor for site I is

(RRF)I = (mean 8-hr daily max.)future/(mean 8-hr daily max.)baseline = 82.1/95.2 = 0.862

**Figure 3.1. Choosing Ozone Predictions To Estimate RRF's**

**(a) Predictions With Baseline Emissions**

**Day 1**

| | | |
|---|---|---|
| 97.2 | 95.5 | 96.2 |
| 97.1 | 95.2 | 89.1 |
| 97.2 | 98.3 | 97.6 |

98.3

**Day 2**

| | | |
|---|---|---|
| 100.2 | 98.5 | 98.1 |
| 100.0 | 99.1 | 97.3 |
| 99.5 | 95.4 | 97.9 |

100.2

**Day 3**

| | | |
|---|---|---|
| 87.8 | 90.1 | 89.9 |
| 90.9 | 91.6 | 88.7 |
| 88.5 | 89.4 | 90.2 |

91.6

**Day 4**

| | | |
|---|---|---|
| 85.9 | 87.9 | 88.9 |
| 87.9 | 90.5 | 90.7 |
| 86.9 | 87.3 | 88.4 |

90.7

**Mean Baseline Ozone Concentration = (98.3 + 100.2 + 91.6 + 90.7) / 4 = 95.2 ppb**

**(b) Predictions With Future Emissions**

**Day 1**

| | | |
|---|---|---|
| 86.1 | 85.4 | 86.8 |
| 86.2 | 84.5 | 84.3 |
| 85.8 | 87.2 | 86.9 |

87.2

**Day 2**

| | | |
|---|---|---|
| 82.2 | 80.8 | 81.2 |
| 82.4 | 79.9 | 80.5 |
| 81.4 | 77.8 | 80.1 |

82.4

**Day 3**

| | | |
|---|---|---|
| 72.1 | 76.1 | 75.5 |
| 74.6 | 77.5 | 74.3 |
| 76.9 | 77.4 | 75.6 |

77.5

**Day 4**

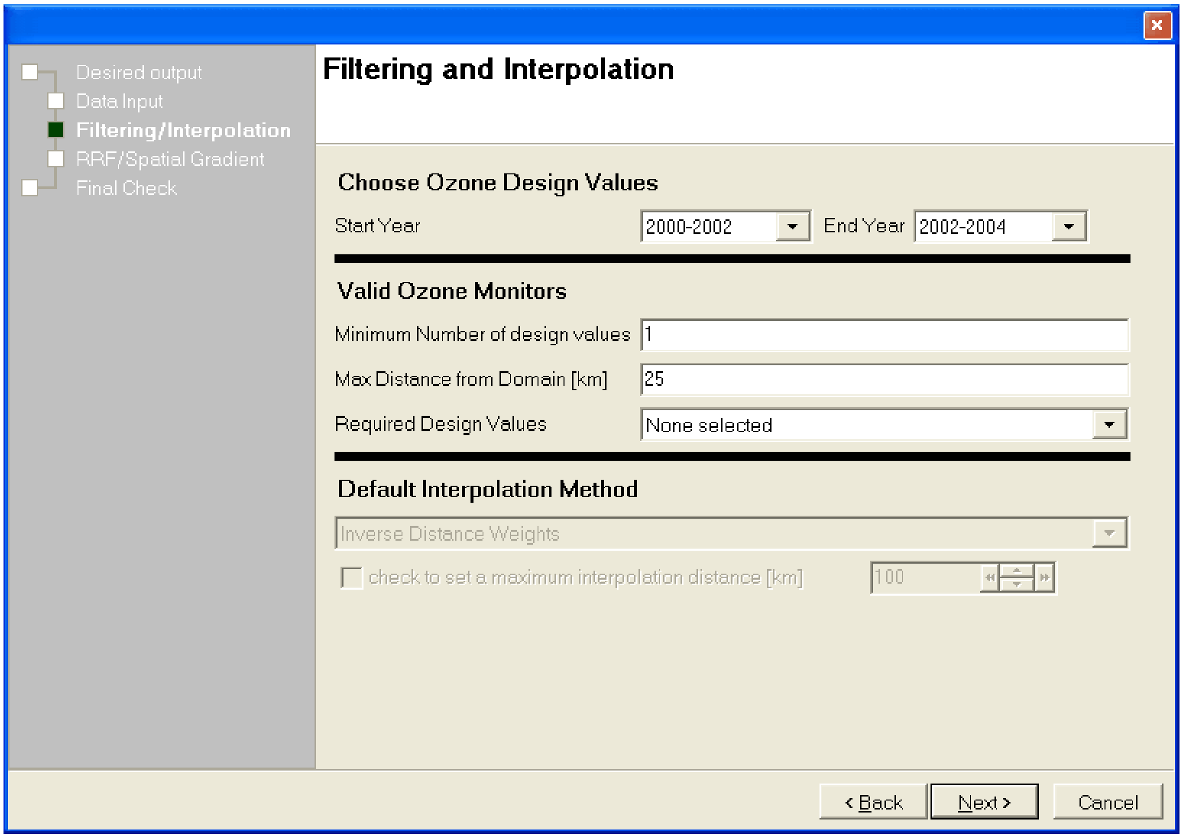
| | | |
|---|---|---|
| 75.4 | 78.8 | 79.8 |
| 80.8 | 79.5 | 80.9 |
| 80.4 | 76.9 | 81.1 |

81.1

**Mean Future Ozone Concentration = (87.2 + 82.4 + 77.5 + 81.1) / 4 = 82.1 ppb**

## 7.3 Filtering and Interpolation

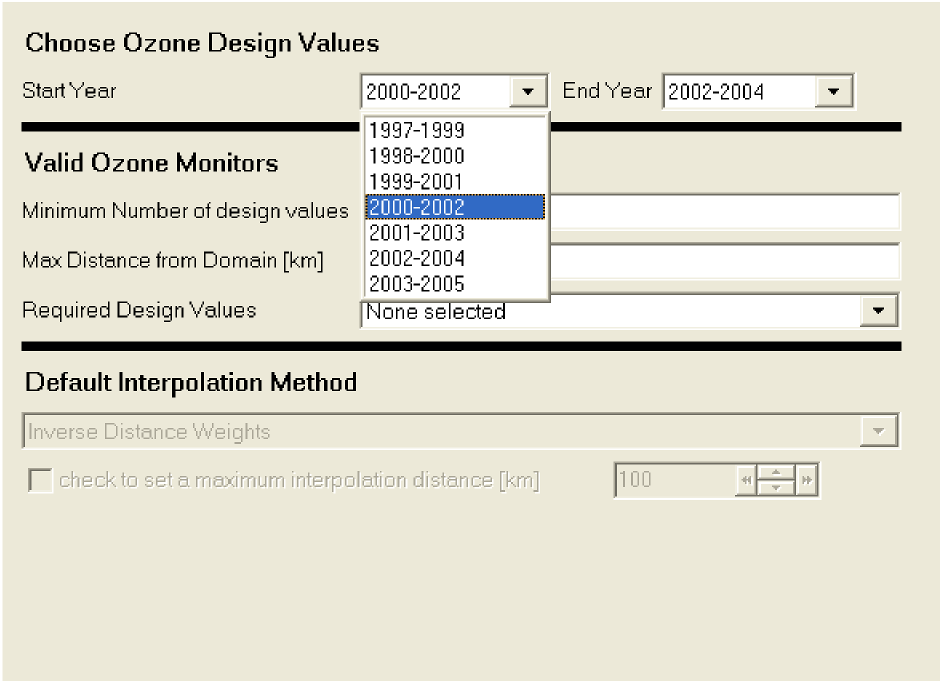
The **Filtering and Interpolation** window allows you to choose the years of monitoring data that you will use in your analysis. MATS allows you to specify the rules to determine the monitors that you will use. And in the case of calculating Spatial Fields, it allows you to define the interpolation method that MATS will use.




## 7.3.1 Choose Ozone Design Values

Choosing the **Start Year** and the **End Year** defines the range of the ozone design values that will be used in the calculation of the baseline ozone level. You can vary the number of design values used in this calculation.

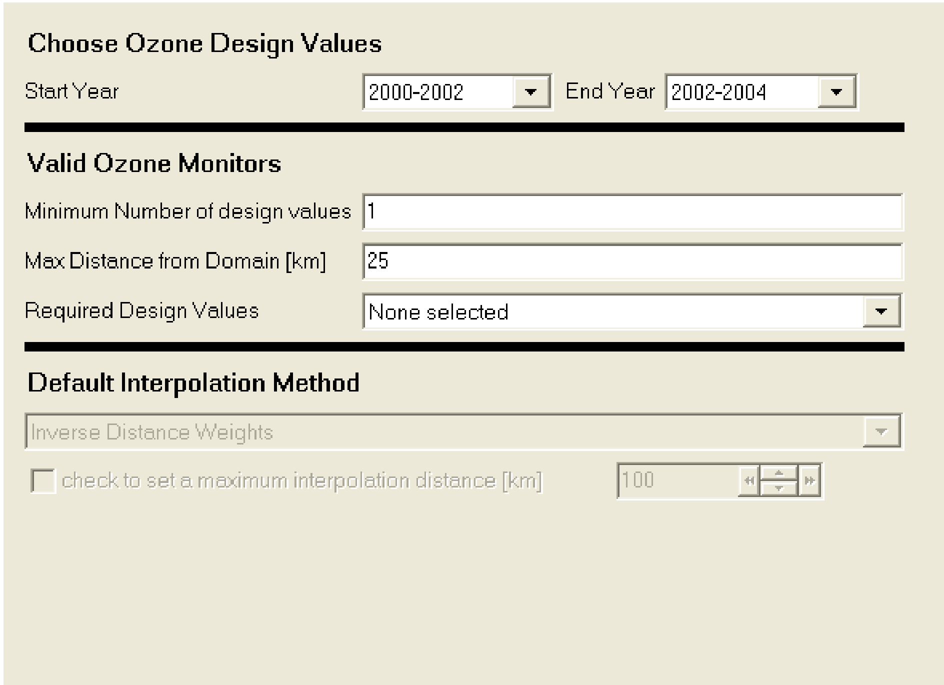
The database that comes with MATS has design values periods from 1997-2005. The default approach in MATS is to average 3 design value periods. For example, if the modeling base year is 2002, then you would use the design values from 2000-2002, 2001-2003, and 2002-2004. The **Start Year** is set to *2000-2002* and the **End Year** is set to *2002-2004.*




### 7.3.2 Valid Ozone Monitors

MATS provides three choices for identifying monitors that are "valid" and thus included in your analysis.

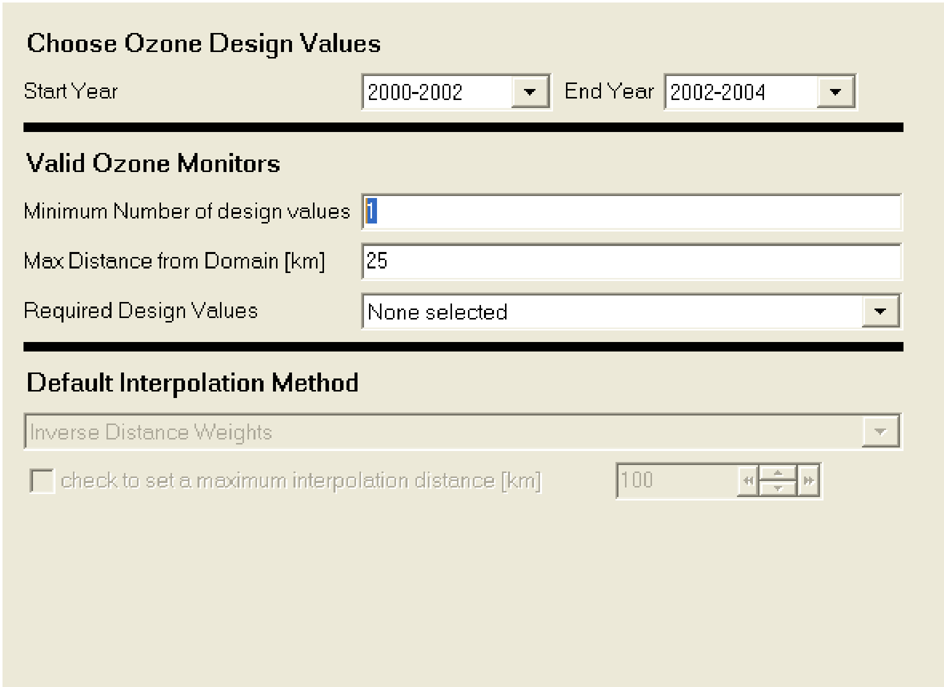
- **Minimum Number of Design Values**. Specifies the minimum number of design value periods that need to be included in the calculation of the baseline ozone design value (1, 2, or 3).
- **Max Distance from Domain [km]**. Specifies how far a monitor may be from a model grid cell and still be included in calculations that use that grid cell's model values. (This is relevant for the calculation of RRFs and gradient-adjustments.)
- **Required Design Values**. Specifies whether a particular design value period needs to be valid for the calculations to be performed at that monitor.




#### 7.3.2.1 Minimum Number Design Values

The **Minimum Number of Design Values** specifies the minimum number of design values that need to be available in the potential range of design values specified by the Start Year and End Year. Monitors that do not meet the minimum are excluded from the calculation of baseline ozone levels.

Recall that the baseline ozone level is an average of one or more design values. The number of design values available for this calculation will typically be either 1, 2, or 3 design value periods. The default option is to require that one design value be available in the specified range.




### Example 1:  Point Estimates

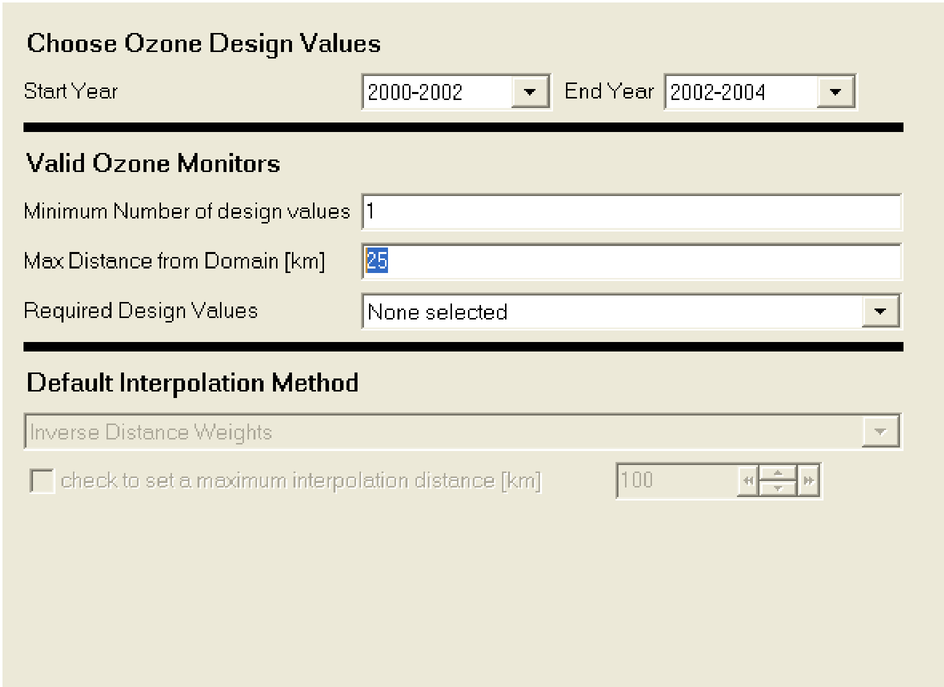
When calculating ozone levels at monitors, if MATS finds that a monitor has an insufficient number of valid design values (e.g., one required but none available in the specified range), then MATS will set the baseline level and forecast values to missing ( denoted by a negative number).

### Example 2:  Spatial Field

The calculation of the ozone level in each grid cell of a Spatial Field involves multiple monitors.  MATS uses Voronoi Neighbor Averaging to identify "neighboring" monitors from the available set of valid monitors, and then calculates an inverse-distance weighted average of the baseline ozone levels from these neighbors.  The **Minimum Number of Design Values** determines which monitors are "valid" -- that is, those monitors that will be included in the calculation.

#### 7.3.2.2 Max Distance from Domain

The option to specify the **Max Distance from Domain** allows you to choose how far (in kilometers) a monitor may be from the  center of a model grid cell and still be included in calculations that use that grid cell's model values.




### Example 1: Point Estimates

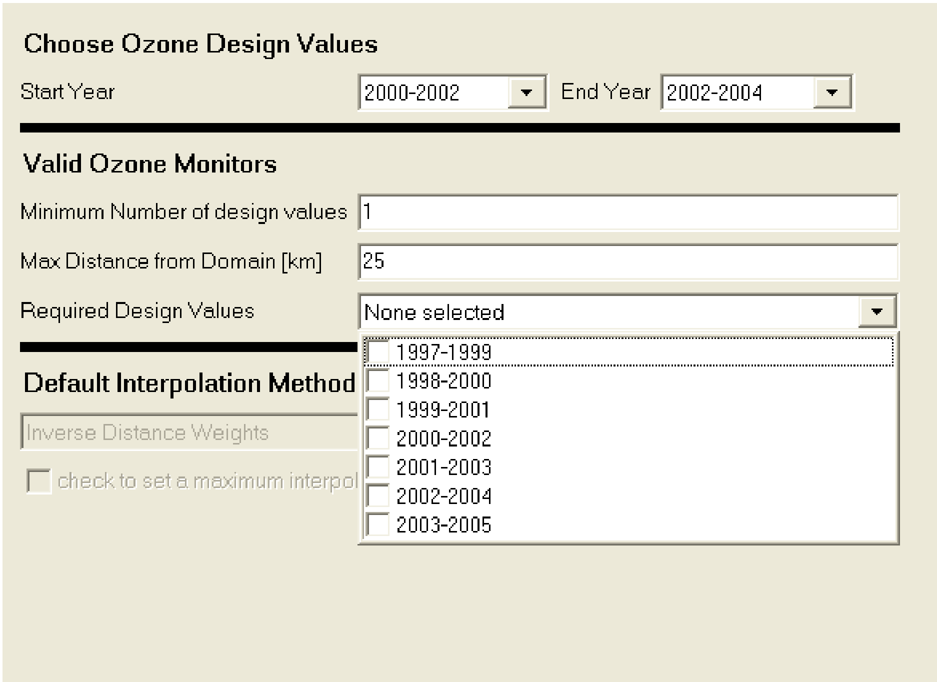
When calculating ozone levels at monitors, if MATS finds that a monitor is further than the specified **Max Distance from Domain**, then MATS will drop the monitor from the analysis. For example, if the Max Distance from Domain is set to 25 kilometers and the model domain includes the continental U.S., then monitors in Alaska, or other locations far from the model domain are excluded from calculations involving model data. If an extremely large distance is specified, say 10,000 kilometers, then all monitors would be included, regardless of the model domain location

### Example 2: Spatial Field

The calculation of the ozone level in each grid cell of a Spatial Field can involve multiple monitors. MATS uses Voronoi Neighbor Averaging to identify "neighboring" monitors from the available set of valid monitors, and then calculates an inverse-distance weighted average of the baseline ozone levels from these neighbors. The **Max Distance from Domain** determines which monitors are "valid" -- that is, those monitors that will be included in the calculation.

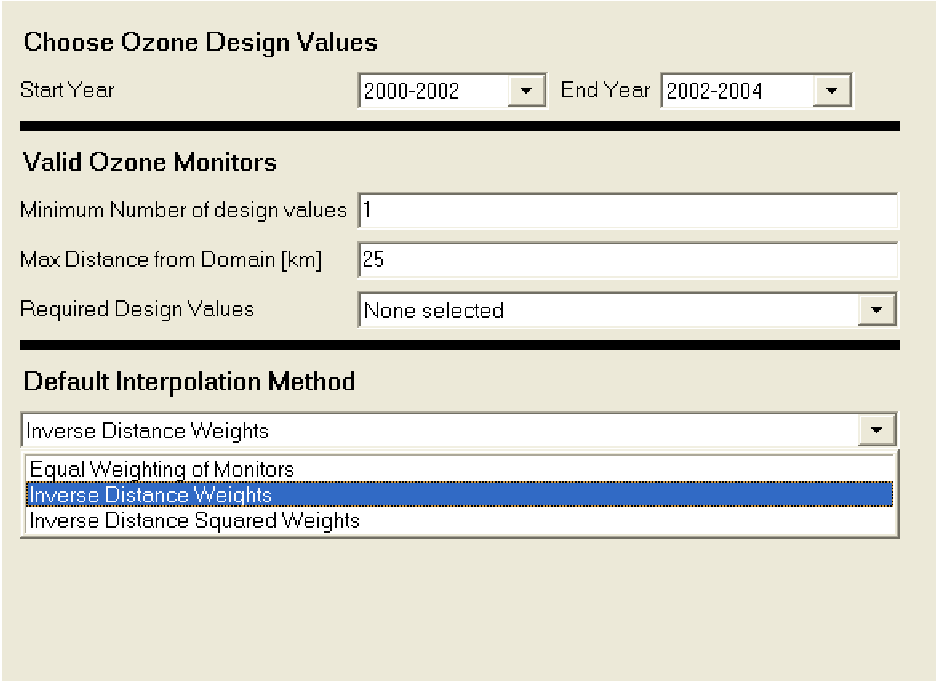
#### 7.3.2.3 Required Design Values

Using the **Required Design Value** drop-down list, you can specify that a particular design value must be available at each monitor included in the analysis. If you want to use all monitors that have a valid design value for 2001-2003, then MATS will only include those monitors that have this valid design value. The default is to choose *None Selected*.



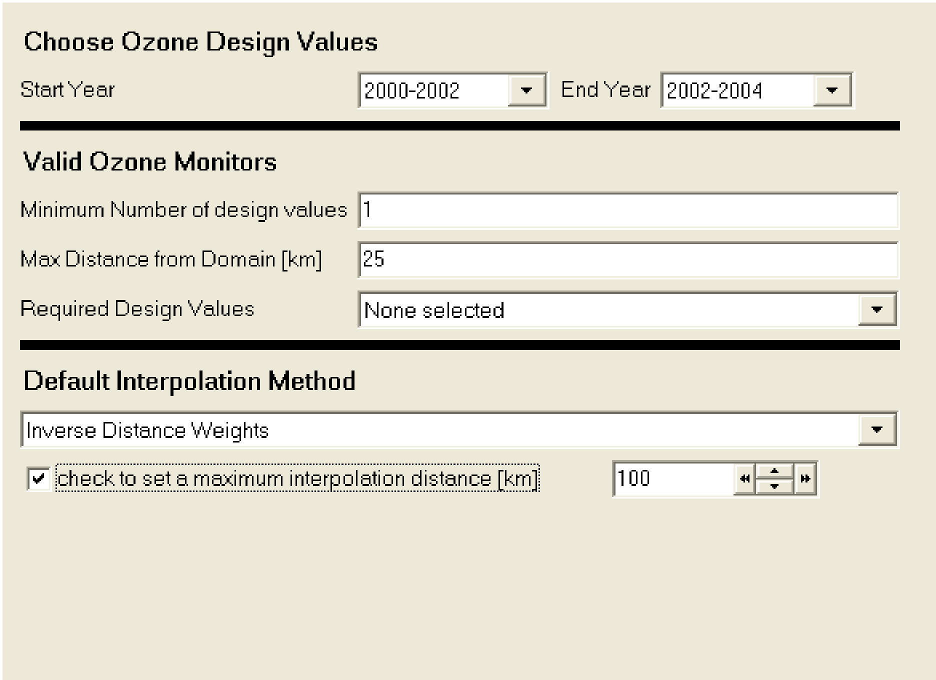

### 7.3.3 Default Interpolation Method

The **Default Interpolation Method** panel allows you to choose how you will interpolate, or combine, the values from different monitors. One approach is to user Inverse Distance Weights. This means that the weight given to any particular monitor is inversely proportional to its distance from the point of interest. A second approach is Inverse Distance Squared Weights, which means that the weights are inversely proportional to the square of the distance. And the third approach is Equal Weighting of Monitors. The default approach for ozone is Inverse Distance Weights.



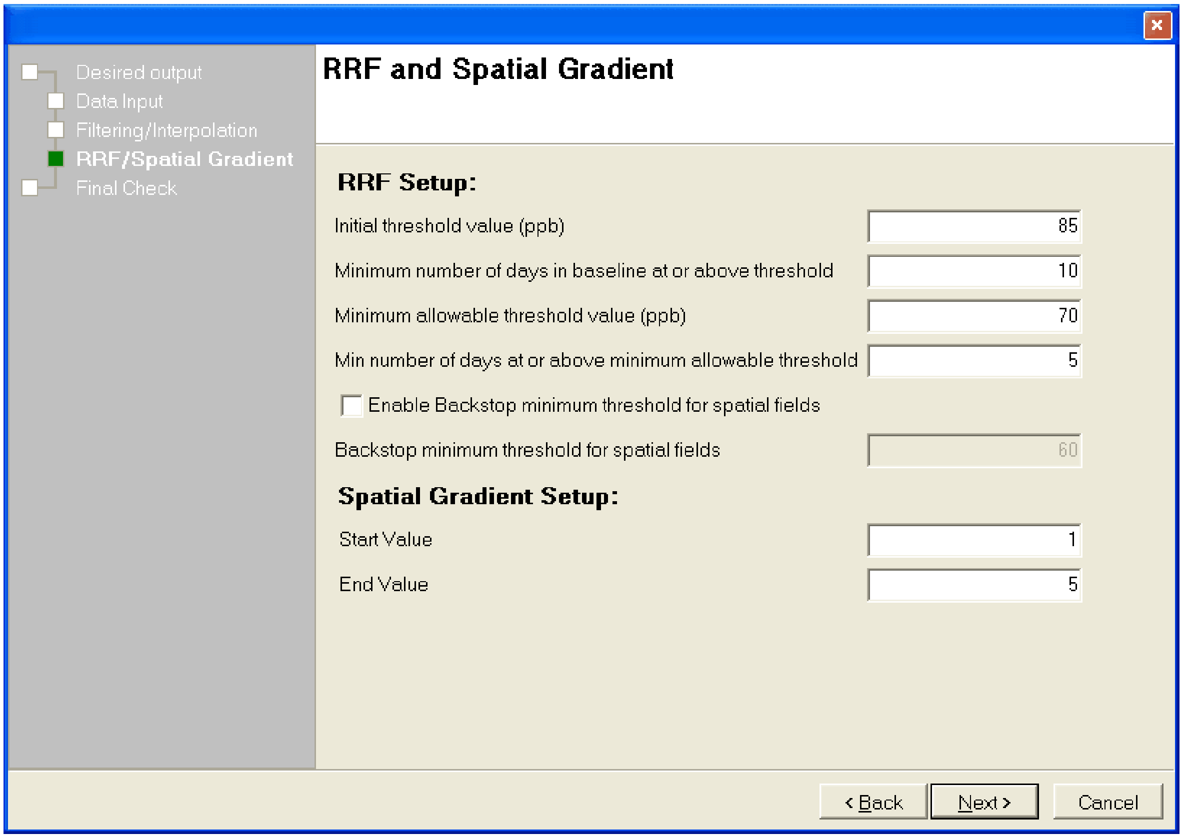

When interpolating monitor values, MATS allows you to identify the monitors you want to use based on their distance away from the point of interest (*e.g.*, the center of a grid cell). The first step in the interpolation process is to identify the monitors that are nearby, or neighbors, for each point of interest. The next step is to determine the distance from the nearby monitors to the point of interest.

The default approach is to include all valid monitors (*i.e.*, those that satisfy the three criteria in the Valid Ozone Monitors panel), regardless of distance. If you want to limit the use of monitors based on distance, check the box next to *check to set a maximum interpolation distance*, and then specify a distance (in kilometers). A distance of one hundred (100) kilometers means that any monitors further than 100 kilometers can no longer be used in the interpolation. If a point of interest has no monitors within the specified distance, then no value is calculated. The default is to leave this box unchecked.




## 7.4 RRF and Spatial Gradient

In calculating an ozone RRF or a Spatial Gradient, typically, not all of the model data are used. In the case of RRFs, daily values falling below specified thresholds can be excluded from the calculation (*e.g.*, RRF Calculation - Example 1). In the case of a spatial gradient, MATS be be setup to follow the same thresholds as used for point estimates or if a valid result is needed in all grid cells, a **Backstop minimum threshold** can be used (*e.g.*, RRF Calculation Spatial Gradient with Backstop Threshold - Example 6). MATS also averages a user-specified range of values to calculate gradient adjustments (*e.g.*, Spatial Gradient Calculation - Example 1).




### 7.4.1 RRF Setup

The RRF Setup involves four variables that specify the thresholds and the numbers of days above the thresholds -- **Initial threshold value**; **Minimum number of days in baseline at or above threshold**; **Minimum allowable threshold value**; and **Min number of days at or above minimum allowable threshold**.

The first step in calculating the RRF is to determines the number of days at or above the **Initial threshold value**. If the number of days is above the **Minimum number of days in baseline at or above threshold,** then MATS averages the 8-hour values for those grid cells with at least this number. For example, MATS performs the following steps:

- In the case of a 3x3 array, MATS identifies the highest daily 8-hour average maximum from among the nine "nearby" grid cells for each day and for each monitor site. In the case where there are 90 days of model outputs, MATS generates 90 daily values. NOTE: MATS does this calculation separately for the baseline and future-year scenarios. As a result two different grid cells in the baseline and future-year might be used to represent a given day.
- The default **Initial threshold value** is set to 85 ppb. The default **Minimum number of days in baseline at or above threshold** is set to 10. If there are fewer than 10 days at or above 85 ppb in the baseline scenario, then MATS lowers the threshold in increments of 1 ppb, until there are at least 10 days at or above this new, lower threshold. This process

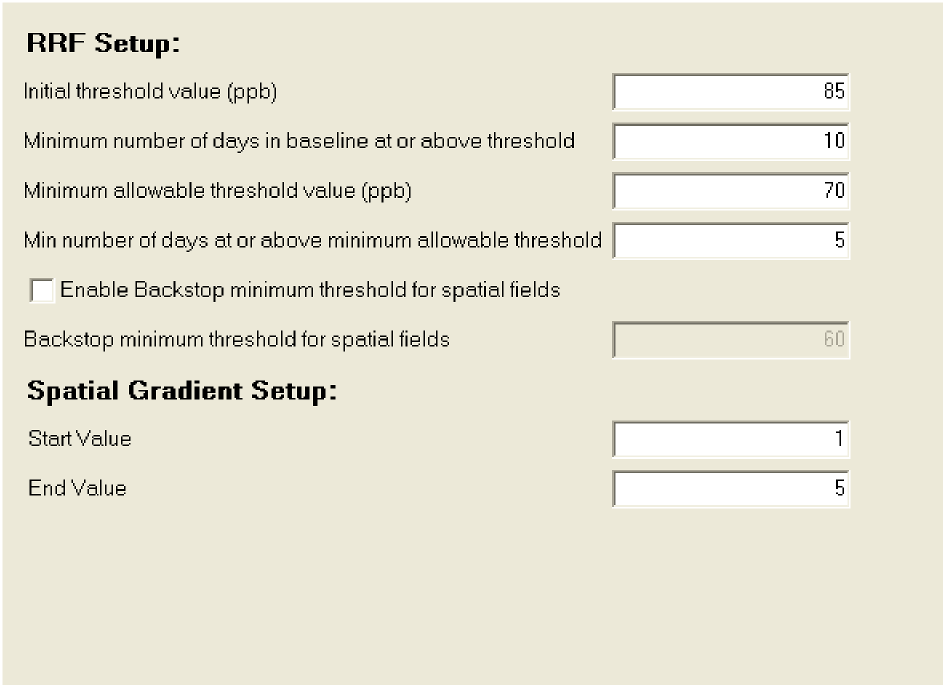
is continued, if needed, until the **Minimum allowable threshold value** is reached. The default **Minimum allowable threshold value** is 70 ppb. MATS calculates the number of days at or above the **Minimum allowable threshold value**. If there are fewer than the **Min number of days at or above minimum allowable threshold**, then the monitor site will be dropped. The default **Min number of days at or above minimum allowable threshold** is 5.

- Using the threshold established with the baseline scenario, MATS checks the daily 8-hour maxima calculated for the baseline scenario, and sets to missing any daily value falling below the threshold. For any day set to missing in the baseline scenario, MATS also sets the corresponding day in the future-year scenario to missing.
- For each monitor site, MATS averages the non-missing daily values for the baseline and future-year scenarios, and then calculates the RRF as the ratio of the future-year average to the baseline average.

You can also set a **Backstop minimum threshold for spatial fields**. As noted in Example 6 (below), the backstop minimum threshold allows the minimum threshold to be lowered to a value below the M**inimum allowable threshold value** until the minimum number of days is reached. The backstop threshold is only used for grid cells which do not have enough days to meet the minimum number of days value with the minimum allowable threshold. The backstop threshold does not change the calculation for grid cells that already meet the minimum number of days.

#### 7.4.1.1 RRF Calculation - Example 1

Assume the following default values:




Assume that there are 15 days of data:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 1 | 103 | 1 | 95 |
| 2 | 112 | 2 | 97 |
| 3 | 98 | 3 | 94 |
| 4 | 97 | 4 | 95 |
| 5 | 95 | 5 | 94 |
| 6 | 95 | 6 | 93 |
| 7 | 94 | 7 | 89 |
| 8 | 92 | 8 | 86 |
| 9 | 90 | 9 | 80 |
| 10 | 85 | 10 | 78 |
| 11 | 89 | 11 | 80 |
| 12 | 88 | 12 | 81 |
| 13 | 85 | 13 | 76 |
| 14 | 78 | 14 | 75 |
| 15 | 78 | 15 | 74 |

MATS will sort the values from high to low based on the Baseline values:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 2 | 112 | 2 | 97 |
| 1 | 103 | 1 | 95 |
| 3 | 98 | 3 | 94 |
| 4 | 97 | 4 | 95 |
| 5 | 95 | 5 | 94 |
| 6 | 95 | 6 | 93 |
| 7 | 94 | 7 | 89 |
| 8 | 92 | 8 | 86 |
| 9 | 90 | 9 | 80 |
| 11 | 89 | 11 | 80 |
| 12 | 88 | 12 | 81 |
| 10 | 85 | 10 | 78 |
| 13 | 85 | 13 | 76 |
| 14 | 78 | 14 | 75 |
| 15 | 78 | 15 | 74 |

Note that Day 2 has the highest Baseline value. And note that the Future values are not sorted high to low, and instead the Future days match the Baseline days.

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are thirteen (13) Baseline values at or above this threshold. Since there are more days than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will use all 13 days.

MATS will take the top 13 days (highlighted in yellow) and then calculate separate averages for the Control and Baseline values:

Control average = 87.5385 ppb

Baseline average = 94.0769 ppb.

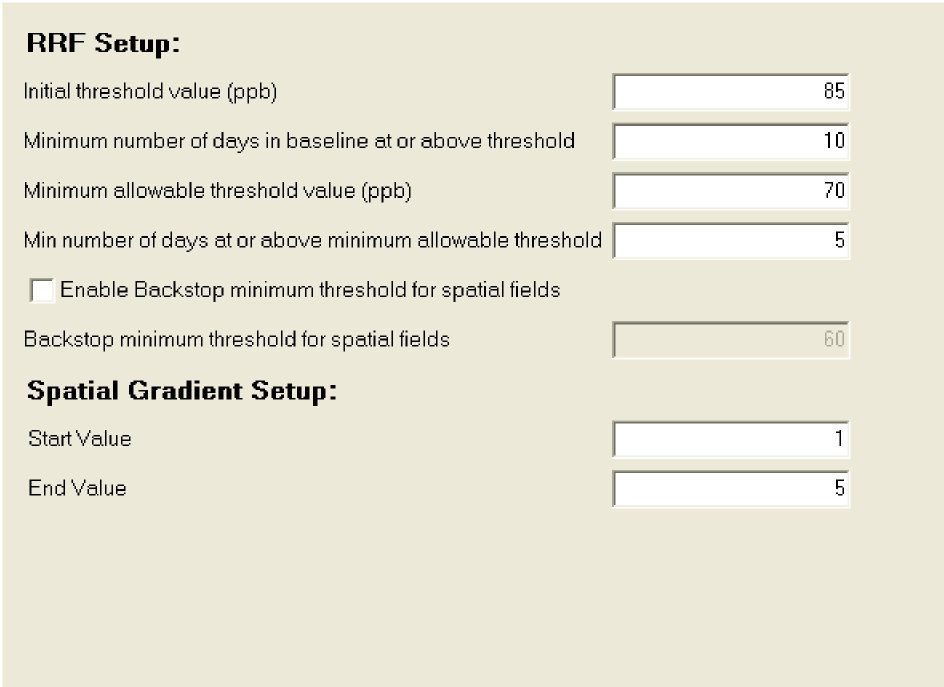
The RRF equals the ratio of the Control to the Baseline:

RRF = 87.5385 / 94.0769 = 0.930

Note that we report the RRF with three digits after the decimal point. The calculation of the Baseline and Control averages does not involve any rounding or truncation.

#### 7.4.1.2 RRF Calculation - Example 2

Assume the following default values:




Assume that there are 15 days of data:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 1 | 100 | 1 | 95 |
| 2 | 100 | 2 | 97 |
| 3 | 98 | 3 | 94 |
| 4 | 97 | 4 | 95 |
| 5 | 95 | 5 | 94 |
| 6 | 95 | 6 | 93 |
| 7 | 90 | 7 | 89 |
| 8 | 85 | 8 | 86 |
| 9 | 84 | 9 | 80 |
| 10 | 83 | 10 | 78 |
| 11 | 83 | 11 | 80 |
| 12 | 83 | 12 | 81 |
| 13 | 79 | 13 | 76 |
| 14 | 78 | 14 | 75 |
| 15 | 78 | 15 | 74 |

MATS will sort the data from high to low based on the Baseline values:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 1 | 100 | 1 | 95 |

| | | | |
|---|---|---|---|
| 2 | 100 | 2 | 97 |
| 3 | 98 | 3 | 94 |
| 4 | 97 | 4 | 95 |
| 5 | 95 | 5 | 94 |
| 6 | 95 | 6 | 93 |
| 7 | 90 | 7 | 89 |
| 8 | 85 | 8 | 86 |
| 9 | 84 | 9 | 80 |
| 10 | 83 | 10 | 78 |
| 11 | 83 | 11 | 80 |
| 12 | 83 | 12 | 81 |
| 13 | 79 | 13 | 76 |
| 14 | 78 | 14 | 75 |
| 15 | 78 | 15 | 74 |

Note that the Baseline values happen to stay in the same order. And note that the Future values are not sorted high to low, and instead the Future days match the Baseline days.

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are only eight (8) Baseline values (highlighted in yellow) at or above this threshold. Since there are fewer days than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will then lower the threshold by one ppb to 84 ppb. There are nine (9) Baseline values at or above this lower threshold -- still less than the value of ten (10) that specified as the Minimum number of days in baseline at or above threshold. MATS will lower the threshold again by one ppb to 83 ppb. At this point, there are twelve (12) days at or above this threshold.

MATS will take the top 12 days:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 1 | 100 | 1 | 95 |
| 2 | 100 | 2 | 97 |
| 3 | 98 | 3 | 94 |
| 4 | 97 | 4 | 95 |
| 5 | 95 | 5 | 94 |
| 6 | 95 | 6 | 93 |
| 7 | 90 | 7 | 89 |
| 8 | 85 | 8 | 86 |
| 9 | 84 | 9 | 80 |
| 10 | 83 | 10 | 78 |
| 11 | 83 | 11 | 80 |
| 12 | 83 | 12 | 81 |
| 13 | 79 | 13 | 76 |
| 14 | 78 | 14 | 75 |
| 15 | 78 | 15 | 74 |

and then calculate separate averages for the Control and Baseline values:

Control average = 88.5000 ppb

Baseline average = 91.0833 ppb.

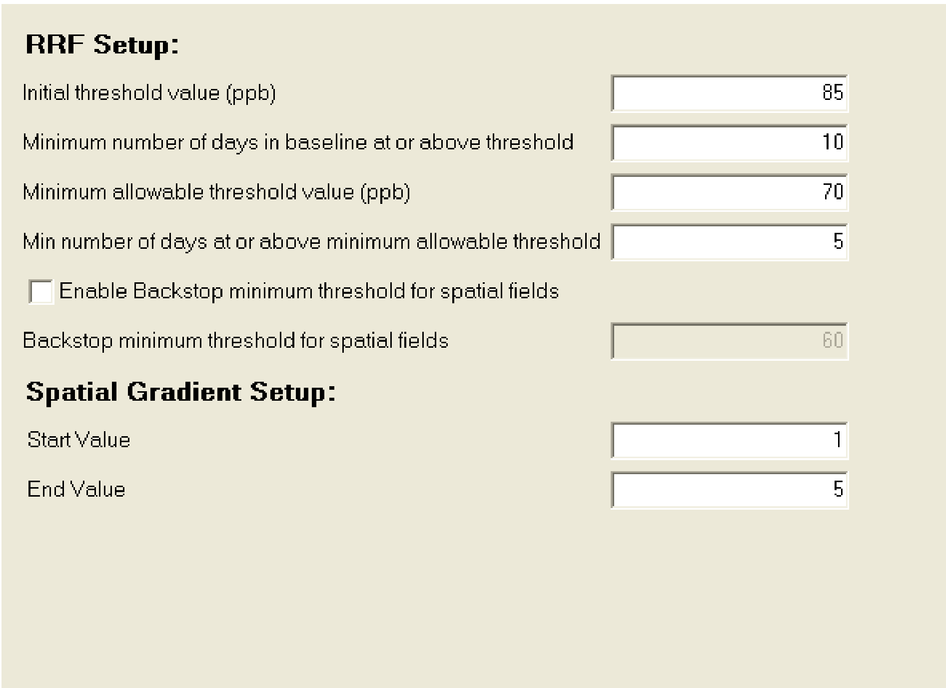
The RRF equals the ratio of the Control to the Baseline:

RRF = 88.5000 / 91.0833 = 0.972

Note that we report the RRF with three digits after the decimal point. The calculation of the Baseline and Control averages does not involve any rounding or truncation.

#### 7.4.1.3 RRF Calculation - Example 3

Assume the following default values:




Assume that there are 15 days of data:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 1 | 84 | 1 | 83 |
| 2 | 85 | 2 | 84 |
| 3 | 85 | 3 | 84 |
| 4 | 82 | 4 | 82 |
| 5 | 78 | 5 | 78 |
| 6 | 76 | 6 | 75 |
| 7 | 70 | 7 | 72 |
| 8 | 70 | 8 | 62 |

| | | | |
|---|---|---|---|
| 9 | 70 | 9 | 70 |
| 10 | 67 | 10 | 62 |
| 11 | 64 | 11 | 63 |
| 12 | 63 | 12 | 60 |
| 13 | 62 | 13 | 62 |
| 14 | 62 | 14 | 59 |
| 15 | 59 | 15 | 57 |

MATS will sort the data from high to low based on the Baseline values:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 2 | 85 | 2 | 84 |
| 3 | 85 | 3 | 84 |
| 1 | 84 | 1 | 83 |
| 4 | 82 | 4 | 82 |
| 5 | 78 | 5 | 78 |
| 6 | 76 | 6 | 75 |
| 7 | 70 | 7 | 72 |
| 8 | 70 | 8 | 62 |
| 9 | 70 | 9 | 70 |
| 10 | 67 | 10 | 62 |
| 11 | 64 | 11 | 63 |
| 12 | 63 | 12 | 60 |
| 13 | 62 | 13 | 62 |
| 14 | 62 | 14 | 59 |
| 15 | 59 | 15 | 57 |

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are only two (2) Baseline values at or above this threshold. Since there are fewer days than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will then lower the threshold by one ppb to 84 ppb. There are three (3) Baseline values at or above this lower threshold -- still less than the value of ten (10) that specified as the Minimum number of days in baseline at or above threshold. MATS will lower the threshold again by one ppb, and eventually get to the Minimum allowable threshold value of 70 ppb. At this point, there are still only nine (9) days at or above this threshold.

MATS will take the nine days (highlighted in yellow) above the Minimum allowable threshold value and then calculate separate averages for the Control and Baseline values:

Control average = 76.6667 ppb

Baseline average = 77.7778 ppb.

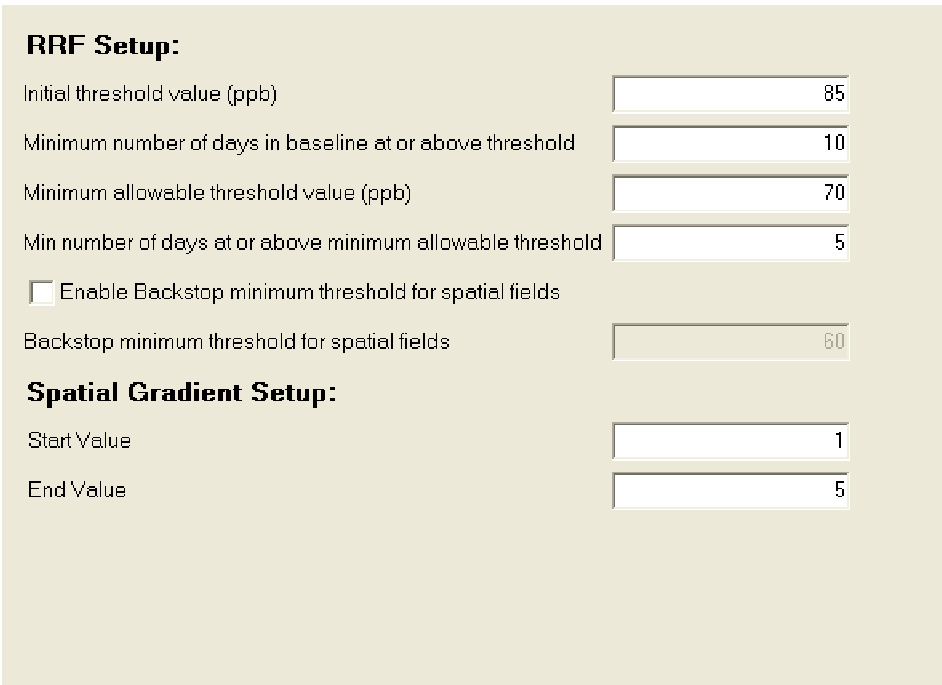
The RRF equals the ratio of the Control to the Baseline:

RRF = 76.6667 / 77.7778 = 0.986

Note that we report the RRF with three digits after the decimal point. The calculation of the Baseline and Control averages does not involve any rounding or truncation.

#### 7.4.1.4 RRF Calculation - Example 4

Assume the following default values:




Assume that there are 15 days of data:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 1 | 67 | 1 | 65 |
| 2 | 74 | 2 | 73 |
| 3 | 70 | 3 | 69 |
| 4 | 68 | 4 | 66 |
| 5 | 78 | 5 | 77 |
| 6 | 66 | 6 | 64 |
| 7 | 66 | 7 | 63 |
| 8 | 65 | 8 | 63 |
| 9 | 63 | 9 | 63 |
| 10 | 62 | 10 | 60 |
| 11 | 61 | 11 | 61 |
| 12 | 60 | 12 | 59 |
| 13 | 60 | 13 | 57 |
| 14 | 59 | 14 | 56 |
| 15 | 57 | 15 | 55 |

MATS will sort the data sorted from high to low based on the Baseline values:

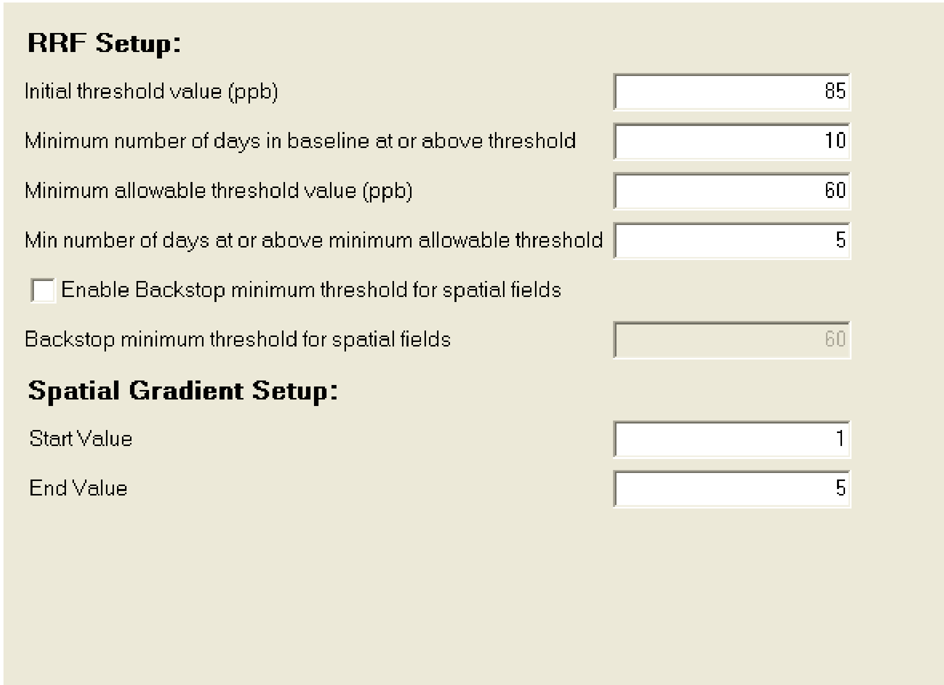
| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 5 | 78 | 5 | 77 |
| 2 | 74 | 2 | 73 |
| 3 | 70 | 3 | 69 |
| 4 | 68 | 4 | 66 |
| 1 | 67 | 1 | 65 |
| 6 | 66 | 6 | 64 |
| 7 | 66 | 7 | 63 |
| 8 | 65 | 8 | 63 |
| 9 | 63 | 9 | 63 |
| 10 | 62 | 10 | 60 |
| 11 | 61 | 11 | 61 |
| 12 | 60 | 12 | 59 |
| 13 | 60 | 13 | 57 |
| 14 | 59 | 14 | 56 |
| 15 | 57 | 15 | 55 |

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are zero (0) Baseline values at or above this threshold. Since there are fewer days than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will lower the threshold by one ppb, and eventually get to the Minimum allowable threshold value of 70 ppb.

At this point, there are still only three (3) days at or above this threshold -- still less than the Min number of days at or above minimum allowable. As a result, MATS will not calculate a RRF and will set the future year design value to missing.

#### 7.4.1.5 RRF Calculation - Example 5

Rather than assume the MATS default values, assume the Minimum allowable threshold value is 60 ppb:




Assume that there are 15 days of data:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 1 | 67 | 1 | 65 |
| 2 | 74 | 2 | 73 |
| 3 | 70 | 3 | 69 |
| 4 | 68 | 4 | 66 |
| 5 | 78 | 5 | 77 |
| 6 | 67 | 6 | 64 |
| 7 | 66 | 7 | 63 |
| 8 | 65 | 8 | 63 |
| 9 | 63 | 9 | 63 |
| 10 | 62 | 10 | 60 |
| 11 | 61 | 11 | 61 |
| 12 | 60 | 12 | 59 |
| 13 | 60 | 13 | 57 |
| 14 | 59 | 14 | 56 |
| 15 | 57 | 15 | 55 |

MATS will sort the data from high to low based on the Baseline values:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 5 | 78 | 5 | 77 |

| | | | |
|---|---|---|---|
| 2 | 74 | 2 | 73 |
| 3 | 70 | 3 | 69 |
| 4 | 68 | 4 | 66 |
| 1 | 67 | 1 | 65 |
| 6 | 67 | 6 | 64 |
| 7 | 66 | 7 | 63 |
| 8 | 65 | 8 | 63 |
| 9 | 63 | 9 | 63 |
| 10 | 62 | 10 | 60 |
| 11 | 61 | 11 | 61 |
| 12 | 60 | 12 | 59 |
| 13 | 60 | 13 | 57 |
| 14 | 59 | 14 | 56 |
| 15 | 57 | 15 | 55 |

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are  zero (0) Baseline values at or above this threshold.  Since there are fewer days than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will lower the threshold by one ppb, and eventually get to the Minimum allowable threshold value of 62 ppb.  At this point, there are ten (10) days at or above this threshold.

MATS will take the ten days (highlighted in yellow) above the Minimum allowable threshold value and then calculate separate averages for the Control and Baseline values:

Control average = 66.3000 ppb

Baseline average = 68.0000 ppb.

The RRF equals the ratio of the Control to the Baseline:

RRF = 66.3000 / 68.0000 = 0.975

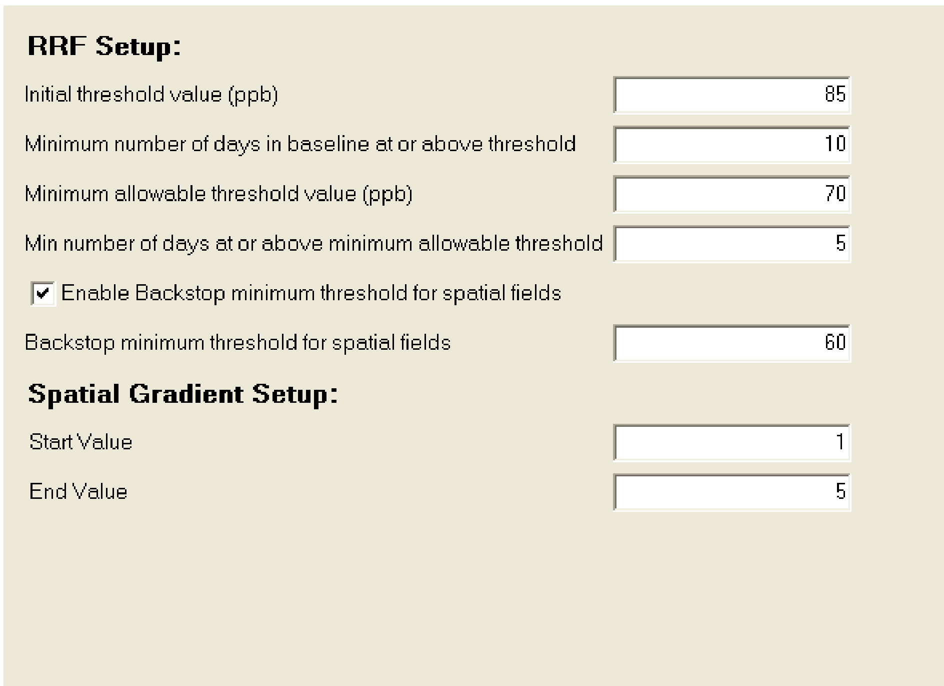
Note that we report the RRF with three digits after the decimal point.  The calculation of the Baseline and Control averages does not involve any rounding or truncation.

#### 7.4.1.6 RRF Calculation Spatial Gradient with Backstop Threshold - Example 6

The following is an example showing the difference between RRF s calculated for Point Estimates and RRFs calculated for Spatial Fields.  The key difference is that MATS allows you to choose a **Backstop minimum threshold for spatial fields**, which applies just to Spatial Fields.  This extra parameter allows you to calculate RRFs for Spatial Fields exactly as you would for Point Estimates, except in the case when the minimum number of days threshold cannot be met (MATS would return a -9 value for point estimates).

An example of such a case of where the two RRF calculations differ is when the number of days at or above the **Minimum allowable threshold value** is less than the **Minimum number of days at or above minimum allowable threshold**.  In this case, MATS would not calculate an RRF for a Point Estimate.  However, if the **Backstop minimum threshold for spatial fields** is set to some value lower than the **Minimum allowable threshold value** , then MATS could potentially calculate an RRF for all or most grid cells in a Spatial Field.

The backstop minimum threshold allows the minimum threshold to be lowered to a value below the M**inimum allowable threshold value** until the minimum number of days is reached. The backstop threshold is only used for grid cells which do not have enough days to meet the minimum number of days value with the minimum allowable threshold. The backstop threshold does not change the calculation for grid cells that already meet the minimum number of days.




Assume that there are 15 days of data for a grid cell:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 1 | 67 | 1 | 65 |
| 2 | 74 | 2 | 73 |
| 3 | 70 | 3 | 69 |
| 4 | 68 | 4 | 66 |
| 5 | 78 | 5 | 77 |
| 6 | 67 | 6 | 64 |
| 7 | 66 | 7 | 63 |
| 8 | 65 | 8 | 63 |
| 9 | 63 | 9 | 63 |
| 10 | 62 | 11 | 61 |
| 11 | 61 | 10 | 60 |
| 12 | 60 | 12 | 59 |
| 13 | 60 | 13 | 57 |
| 14 | 59 | 14 | 56 |

| | | | |
|---|---|---|---|
| 15 | 57 | 15 | 55 |

MATS will sort the data from high to low based on the Baseline values:

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 5 | 78 | 5 | 77 |
| 2 | 74 | 2 | 73 |
| 3 | 70 | 3 | 69 |
| 4 | 68 | 4 | 66 |
| 1 | 67 | 1 | 65 |
| 6 | 67 | 6 | 64 |
| 7 | 66 | 7 | 63 |
| 8 | 65 | 8 | 63 |
| 9 | 63 | 9 | 63 |
| 10 | 62 | 11 | 61 |
| 11 | 61 | 10 | 60 |
| 12 | 60 | 12 | 59 |
| 13 | 60 | 13 | 57 |
| 14 | 59 | 14 | 56 |
| 15 | 57 | 15 | 55 |

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are  zero (0) Baseline values at or above this threshold.  Since there are fewer days than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will lower the threshold by one ppb, and eventually get to the Minimum allowable threshold value of 70 ppb.

At this point, there are still only three (3) Baseline values (highlighted in yellow) at or above this lower threshold -- still less than the value of ten (10) that specified as the Minimum number of days in baseline at or above threshold.  This fails the test for calculating an RRF for a Point Estimate.  However, there is still a possibility that MATS can calculate an RRF for a Spatial Field.  MATS just needs to find at least five values

MATS will lower the threshold again by one ppb.  At a threshold of 68 ppb, there are four (4) days.  MATS will lower the threshold again by one ppb.  At a value of 67 ppb, there are six (6) days at or above the Backstop minimum threshold for spatial fields.

| Baseline day | Baseline value | Future day | Future value |
|---|---|---|---|
| 5 | 78 | 5 | 77 |
| 2 | 74 | 2 | 73 |
| 3 | 70 | 3 | 69 |
| 4 | 68 | 4 | 66 |
| 1 | 67 | 1 | 65 |
| 6 | 67 | 6 | 64 |
| 7 | 66 | 7 | 63 |

| | | | |
|---|---|---|---|
| 8 | 65 | 8 | 63 |
| 9 | 63 | 9 | 63 |
| 10 | 62 | 11 | 61 |
| 11 | 61 | 10 | 60 |
| 12 | 60 | 12 | 59 |
| 13 | 60 | 13 | 57 |
| 14 | 59 | 14 | 56 |
| 15 | 57 | 15 | 55 |

Since MATS is looking for at least five days, MATS will take these six days (highlighted in yellow) above the Backstop minimum threshold for spatial fields and then calculate separate averages for the Control and Baseline values:

Control average = 70.0000 ppb

Baseline average = 71.4000 ppb.

The RRF equals the ratio of the Control to the Baseline:

RRF = 70.0000 / 71.4000 = 0.980

Note that we report the RRF with three digits after the decimal point. The calculation of the Baseline and Control averages does not involve any rounding or truncation.

### 7.4.2 Spatial Gradient Setup

In using a spatial gradient to estimate ozone levels, MATS estimates ozone levels in *unmonitored* locations by using the values of a nearby monitored data scaled by a ratio of model values. The ratio, or spatial gradient, is a mean of model values at the unmonitored location over the mean of the model values at a monitor.

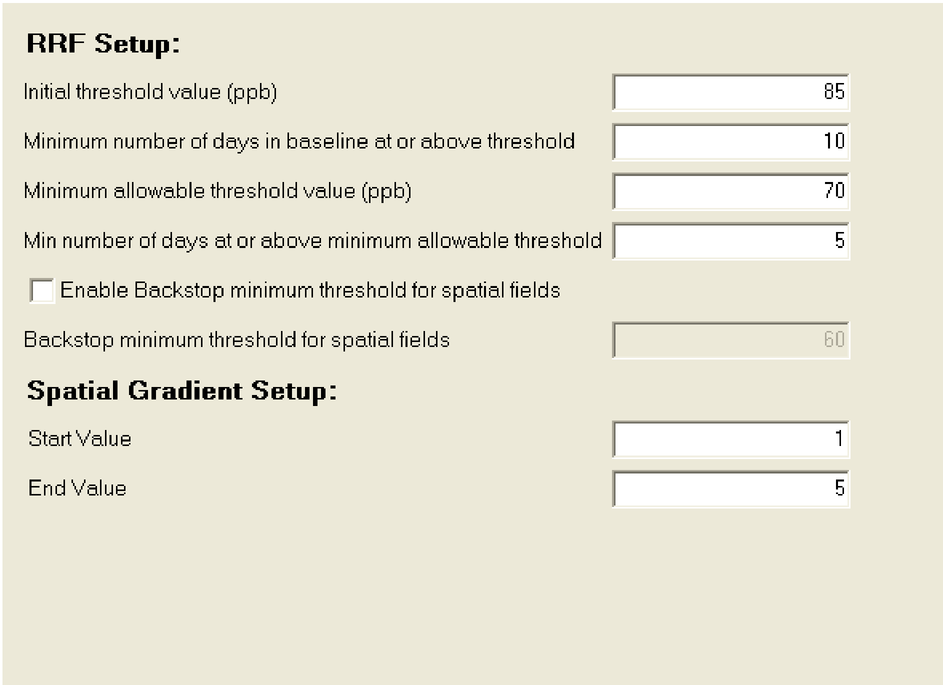
Note that several "nearby" monitors (and their associated model values) are used in the calculation of ozone values at an unmonitored location. MATS uses a process called Voronoi Neighbor Averaging (VNA) to identify these neighbors, and then takes an inverse distance-weighted average of these monitors.

MATS sorts the daily 8-hour maximum ozone values from high to low, averages a certain number of these values (by default the top five), and then uses these averages in the calculation of the spatial gradient. Note that the highest days for Cell A and Cell E are determined independently of each other.

If you want to use a different set of days for the gradient adjustment, you can do so with the **Start Value** and **End Value**. MATS assigns an index of value of 1 to the highest daily 8-hour maximum ozone value in each grid cell. The second-highest an index value of 2. And so on. Using the **Start Value** and the **End Value**, you can identify the values that you want to average by using this index.

#### 7.4.2.1 Spatial Gradient Calculation - Example 1

Assume a Start Value of "1" and an End Value of "5":




For this example calculation, assume that we have one monitor and we want to use this monitor to estimate the ozone level at the center of a nearby grid cell. Further assume that the monitor resides in grid cell "A" and the we want to estimate the ozone level in grid cell "E".

With the default Start Value equal to one (1) and the default End Value, equal to five (5), MATS will average the five highest daily 8-hour maximum ozone values. Note, however, that the highest days for Cell A and Cell E are determined independently of each other.

Assume that there are 15 days of data:

| Day | Cell A | Day | Cell E |
|---|---|---|---|
| 1 | 100 | 1 | 68 |
| 2 | 100 | 2 | 73 |
| 3 | 98 | 3 | 74 |
| 4 | 97 | 4 | 78 |
| 5 | 95 | 5 | 72 |
| 6 | 95 | 6 | 69 |
| 7 | 90 | 7 | 77 |
| 8 | 85 | 8 | 63 |
| 9 | 84 | 9 | 65 |
| 10 | 83 | 10 | 61 |
| 11 | 83 | 11 | 60 |
| 12 | 83 | 12 | 62 |
| 13 | 79 | 13 | 58 |

| | | | |
|---|---|---|---|
| 14 | 78 | 14 | 56 |
| 15 | 78 | 15 | 57 |

MATS will sort the data for cell A from high to low. Independently, MATS will also sort the data for Cell E from high to low. In this example, Day 1 has the highest value for cell A, while the highest value for cell E falls on Day 2.

| Day | Cell A | Day | Cell E |
|---|---|---|---|
| 1 | 100 | 4 | 78 |
| 2 | 100 | 7 | 77 |
| 3 | 98 | 3 | 74 |
| 4 | 97 | 2 | 73 |
| 5 | 95 | 5 | 72 |
| 6 | 95 | 6 | 69 |
| 7 | 90 | 1 | 68 |
| 8 | 85 | 9 | 65 |
| 9 | 84 | 8 | 63 |
| 10 | 83 | 12 | 62 |
| 11 | 83 | 10 | 61 |
| 12 | 83 | 11 | 60 |
| 13 | 79 | 13 | 58 |
| 14 | 78 | 15 | 57 |
| 15 | 78 | 14 | 56 |

MATS will take the top 5 days (highlighted in yellow) and then calculate separate averages for cell A and cell E:

cell E average = 74.8000 ppb

cell A average = 98.0000 ppb.

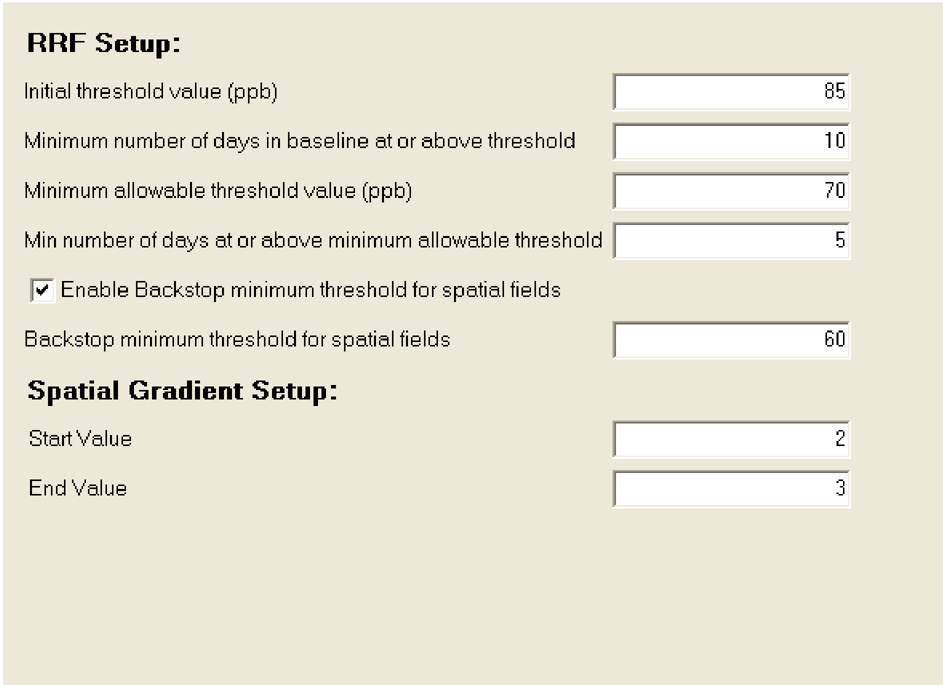
The Spatial Gradient equals the ratio of Cell E to Cell A:

Spatial Gradient = 74.8000 / 98.0000 = 0.763

Note that we report the Spatial Gradient with three digits after the decimal point. The calculation of the averages does not involve any rounding or truncation.

#### 7.4.2.2 Spatial Gradient Calculation - Example 2

Assume a Start Value of "2" and an End Value of "3":




For this example calculation, assume that we have one monitor and we want to use this monitor to estimate the ozone level at the center of a nearby grid cell. Further assume that the monitor resides in grid cell "A" and the we want to estimate the ozone level in grid cell "E".

With the default Start Value equal to two (2) and the default End Value, equal to three (3), MATS will average the second and third highest daily 8-hour maximum ozone values.

Assume that there are 15 days of data:

| Day | Cell A | Day | Cell E |
|---|---|---|---|
| 1 | 100 | 1 | 68 |
| 2 | 100 | 2 | 73 |
| 3 | 98 | 3 | 74 |
| 4 | 97 | 4 | 78 |
| 5 | 95 | 5 | 72 |
| 6 | 95 | 6 | 69 |
| 7 | 90 | 7 | 77 |
| 8 | 85 | 8 | 63 |
| 9 | 84 | 9 | 65 |
| 10 | 83 | 10 | 61 |
| 11 | 83 | 11 | 60 |
| 12 | 83 | 12 | 62 |
| 13 | 79 | 13 | 58 |
| 14 | 78 | 14 | 56 |
| 15 | 78 | 15 | 57 |

MATS will sort the data for cell A from high to low. Independently, MATS will also sort the data for Cell E from high to low.

| Day | Cell A | Day | Cell E |
|---|---|---|---|
| 1 | 100 | 4 | 78 |
| 2 | 100 | 7 | 77 |
| 3 | 98 | 3 | 74 |
| 4 | 97 | 2 | 73 |
| 5 | 95 | 5 | 72 |
| 6 | 95 | 6 | 69 |
| 7 | 90 | 1 | 68 |
| 8 | 85 | 9 | 65 |
| 9 | 84 | 8 | 63 |
| 10 | 83 | 12 | 62 |
| 11 | 83 | 10 | 61 |
| 12 | 83 | 11 | 60 |
| 13 | 79 | 13 | 58 |
| 14 | 78 | 15 | 57 |
| 15 | 78 | 14 | 56 |

MATS will take the second and third highest days (highlighted in yellow) and then calculate separate averages for cell A and cell E:

cell E average = 75.5000 ppb

cell A average = 99.0000 ppb.

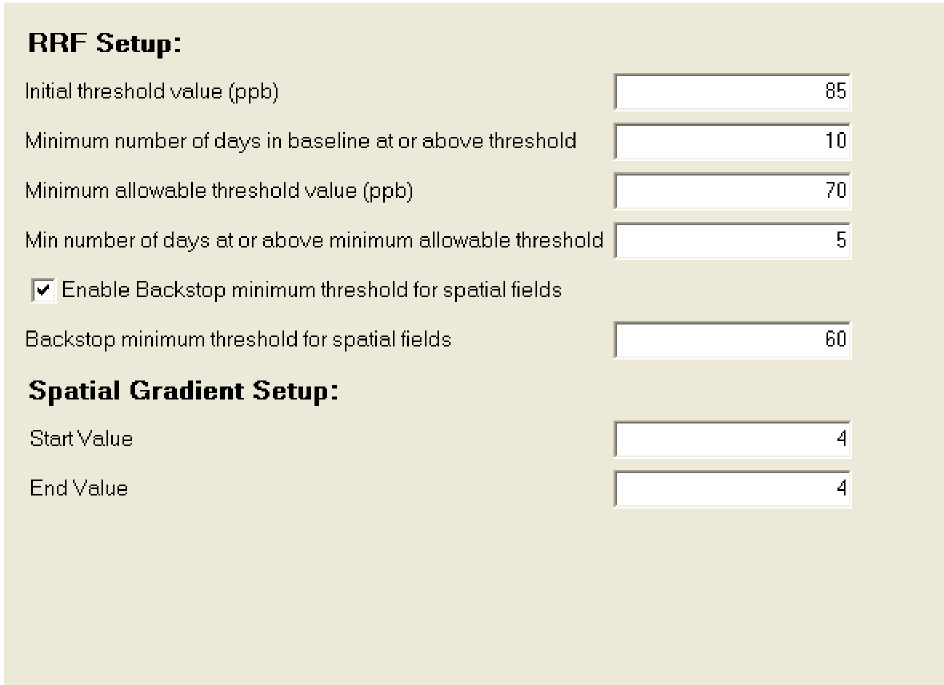
The Spatial Gradient equals the ratio of Cell E to Cell A:

Spatial Gradient = 75.5000 / 99.0000 = 0.763

Note that we report the Spatial Gradient with three digits after the decimal point. The calculation of the averages does not involve any rounding or truncation.

#### 7.4.2.3 Spatial Gradient Calculation - Example 3

Assume a Start Value of "4" and an End Value of "4":




For this example calculation, assume that we have one monitor and we want to use this monitor to estimate the ozone level at the center of a nearby grid cell. Further assume that the monitor resides in grid cell "A" and the we want to estimate the ozone level in grid cell "E".

With the default Start Value equal to four (4) and the default End Value, equal to four (4), MATS will only use the fourth highest daily 8-hour maximum ozone value in each grid cell.

Assume that there are 15 days of data:

| Day | Cell A | Day | Cell E |
|---|---|---|---|
| 1 | 100 | 1 | 68 |
| 2 | 100 | 2 | 73 |
| 3 | 98 | 3 | 74 |
| 4 | 97 | 4 | 78 |
| 5 | 95 | 5 | 72 |
| 6 | 95 | 6 | 69 |
| 7 | 90 | 7 | 77 |
| 8 | 85 | 8 | 63 |
| 9 | 84 | 9 | 65 |
| 10 | 83 | 10 | 61 |
| 11 | 83 | 11 | 60 |
| 12 | 83 | 12 | 62 |
| 13 | 79 | 13 | 58 |
| 14 | 78 | 14 | 56 |
| 15 | 78 | 15 | 57 |

MATS will sort the data for cell A from high to low. Independently, MATS will also sort the data for Cell E from high to low.

| Day | Cell A | Day | Cell E |
|---|---|---|---|
| 1 | 100 | 4 | 78 |
| 2 | 100 | 7 | 77 |
| 3 | 98 | 3 | 74 |
| 4 | 97 | 2 | 73 |
| 5 | 95 | 5 | 72 |
| 6 | 95 | 6 | 69 |
| 7 | 90 | 1 | 68 |
| 8 | 85 | 9 | 65 |
| 9 | 84 | 8 | 63 |
| 10 | 83 | 12 | 62 |
| 11 | 83 | 10 | 61 |
| 12 | 83 | 11 | 60 |
| 13 | 79 | 13 | 58 |
| 14 | 78 | 15 | 57 |
| 15 | 78 | 14 | 56 |

MATS will take the fourth highest day (highlighted in yellow) for cell A and cell E:

cell E = 73 ppb

cell A = 97 ppb.

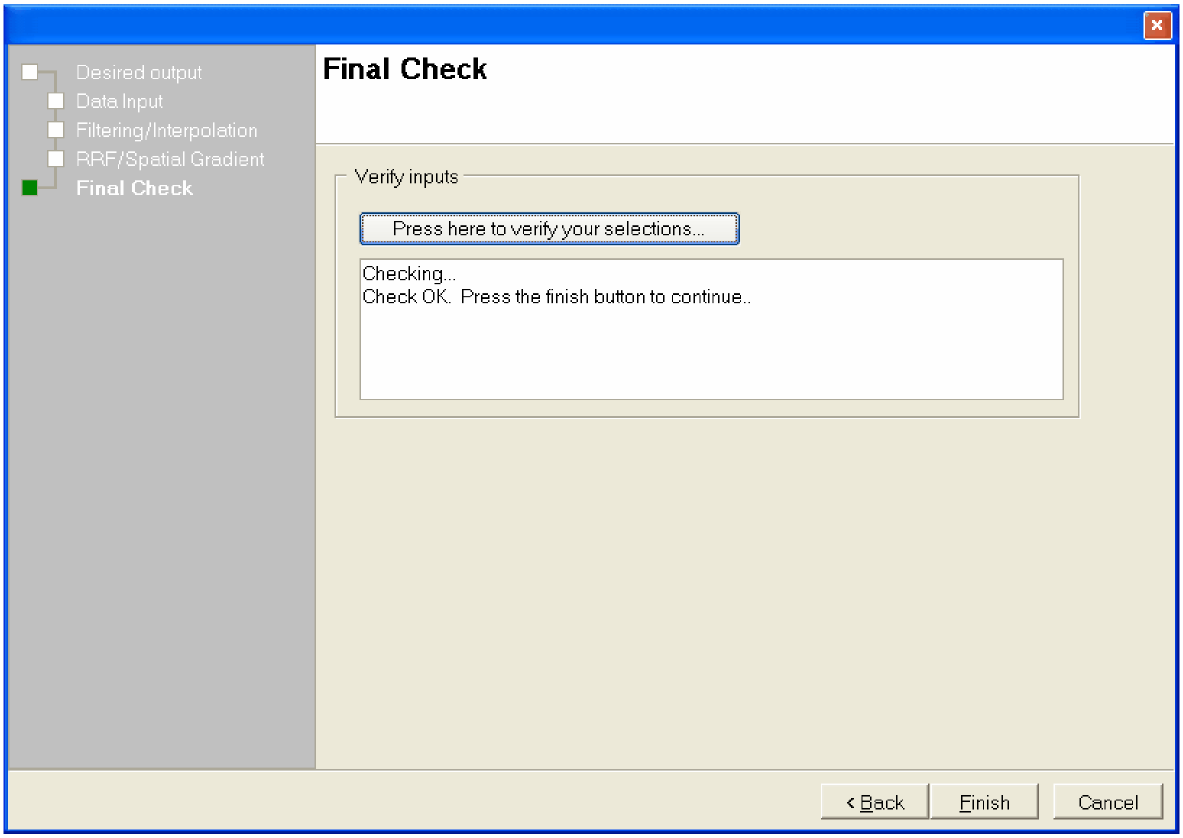
The Spatial Gradient equals the ratio of Cell E to Cell A:

Spatial Gradient = 73 / 97 = 0.753

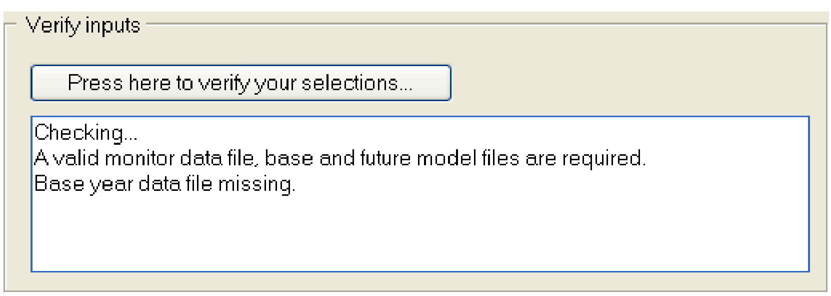
Note that we report the Spatial Gradient with three digits after the decimal point.

## 7.5 Final Check

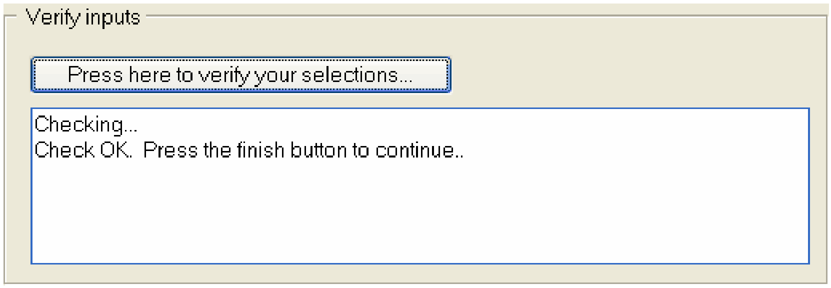
The **Final Check** window verifies the selections that you have made.




Click the button **Press here to verify your selections**. If there are any errors, MATS will present a message letting you know. For example, if the path to a model file is invalid -- perhaps you misspelled the file name -- you would get the following error:




After making the necessary correction, click the button **Press here to verify your selections**. Then click the **Finish** button.


Verify inputs
Press here to verify your selections...
Checking...
Check OK.  Press the finish button to continue..

# 8 Visibility Analysis: Quick Start Tutorial

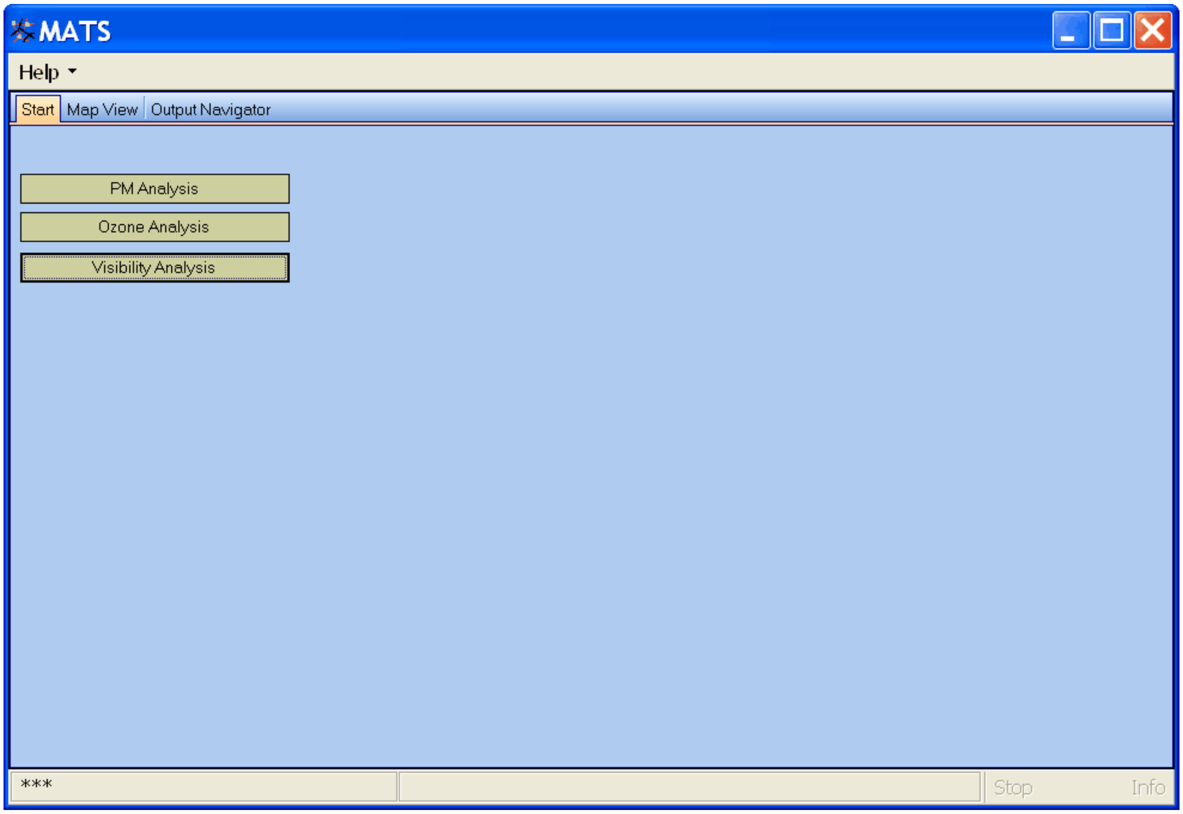
In this tutorial you will forecast visibility levels at Class I Areas in the United States. The steps in this analysis are as follows:

- Step 1. Start MATS. Start the MATS program and choose to do a Visibility analysis.
- Step 2. Desired Output. Choose the output to generate. In this example, you will forecast visibility levels using the new IMPROVE algorithm and model data at the IMPROVE monitors.
- Step 3. Data Input. Choose the data files for input to MATS.
- Step 4. Filtering. Choose the years of monitor and model data that you want to use, and then choose the particular monitors in these data that you want to include in the analysis.
- Step 5. Final Check. Verify the choices you have made.
- Step 6. Load & Map Results**.** Load your results and prepare maps of your forecasts.
- Step 7. Working with Configuration File. Examine the Configuration file that stores the choices that you made underlying your analysis.

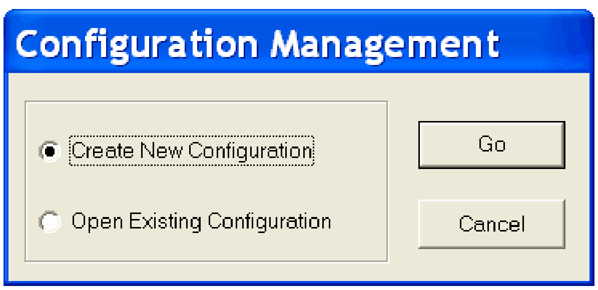
Each step is explained in detail below.

## 8.1 Step 1. Start MATS

Double-click on the MATS icon on your desktop, and the following window will appear:




Click the **Visibility Analysis** button on the main MATS window. This will bring up the **Configuration Management** window.




A Configuration allows you to keep track of the choices that you make when using MATS. For example, after generating results in MATS, you can go back, change one of your choices, rerun your analysis, and then see the impact of this change without having to enter in all of your other choices. For this example, we will start with a new Configuration.

Choose **Create New Configuration** and click the **Go** button. This will bring up the Choose Desired Output window.

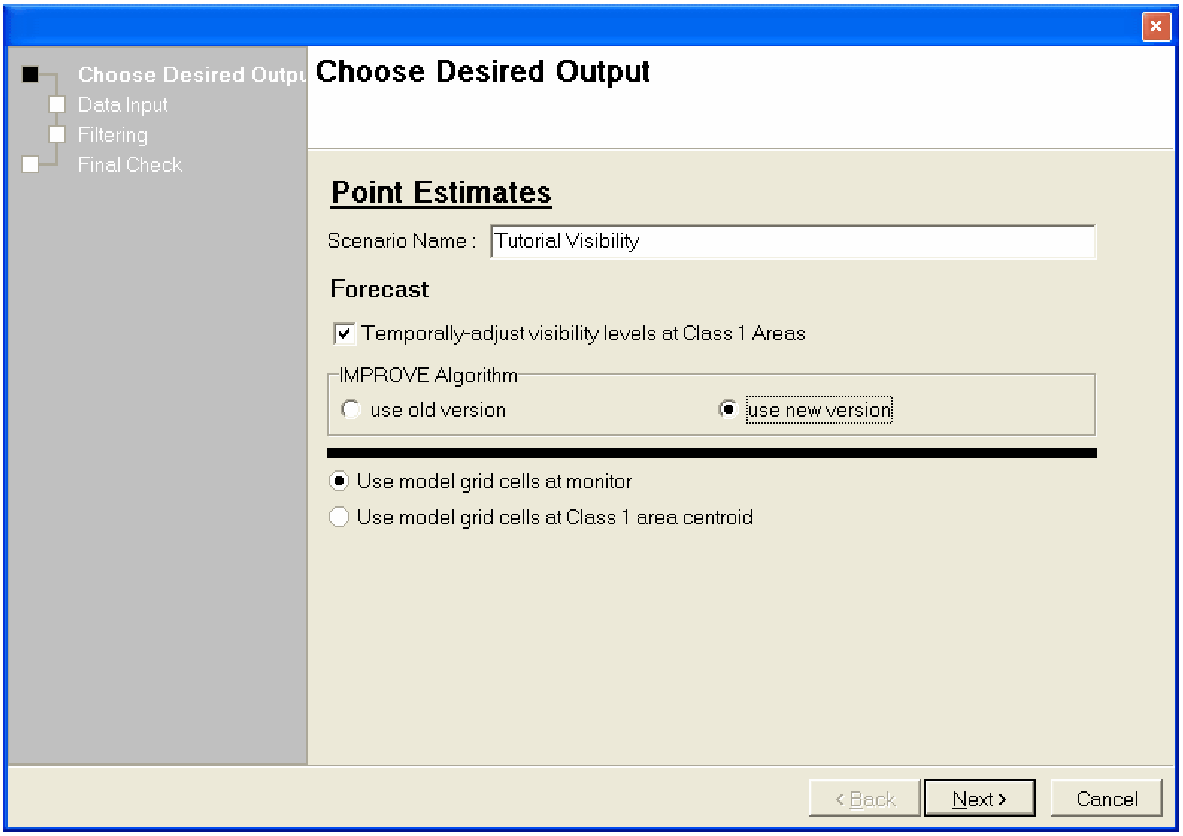
## 8.2 Step 2. Desired Output

The Choose Desired Output window allows you to choose the output that you would like to generate. MATS allows you to calculate future year (forecast) visibility levels at Class I Areas.

In the **Scenario Name** box type "Tutorial Visibility" – this will be used to keep track of where your results are stored and the variable names used in your results files. Leave the box checked next to **Temporally-adjust visibility levels at Class I Areas.** MATS will create forecasts for each Class I Area in your modeling domain.

MATS provides two algorithms for calculating visibility -- an "*old version*" and a "*new version*" of the IMPROVE visibility algorithm (see IMPROVE 2006) (The old and new versions are discussed in Desired Output section of the Visibility Analysis: Details chapter.) Choose the new version.

A single IMPROVE monitor is associated with each Class I Area. MATS multiplies the monitor value with a relative response factor (RRF), which is the the modeled future-year visibility divided the modeled current-year visibility. In calculating the RRF, MATS allows you to use either the model values in the grid cell at the IMPROVE monitor or to use the model values in the grid cell at the Class I Area centroid. Choose the default option of using model values in the grid cell at the monitor. (For additional details see the Desired Output section of the Visibility Analysis: Details chapter.)



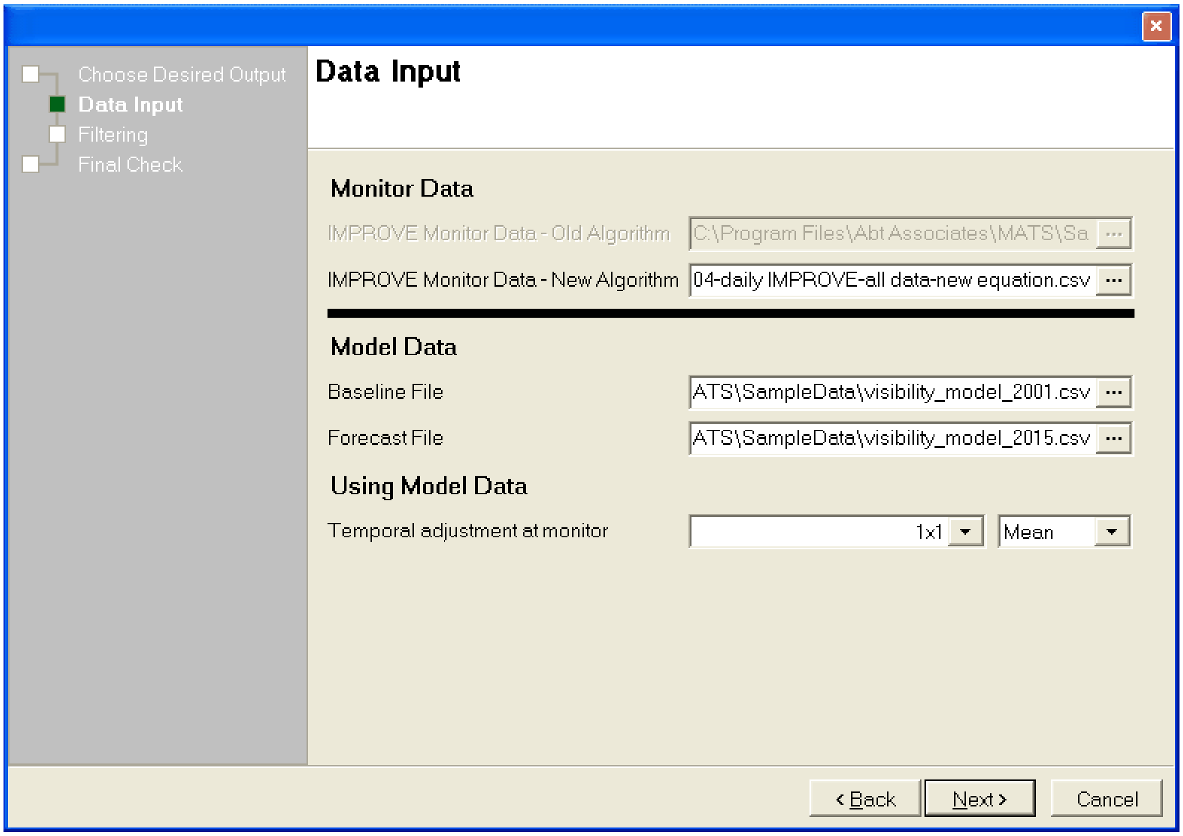

When your window looks like the window above, click **Next**. This will bring up the Data Input window.

## 8.3 Step 3. Data Input

The **Data Input** window allows you to choose the monitor data and the model data that you want to use. As discussed in more detail in the Visibility Analysis: Details chapter, MATS calculates the ratio of the model data to calculate a relative response factor (RRF) for the 20% best and 20% worst visibility days separately. MATS then multiplies the visibility level measured at the monitor for the best days with the RRF for the best days to calculate a future-year estimate for visibility on the best visibility days. MATS performs an analogous calculation for the worst visibility days.

MATS comes loaded with IMPROVE visibility monitor values from 2000 through 2004. It also comes loaded with an example model output dataset for visibility for 2001 and 2015. These are the key ingredients for creating your visibility forecasts.

Use the default settings in the **Data Input** window. The window should look like the following:




Note that MATS gives you the option to use model data in different ways when calculating forecasts at each monitor. The example model datasets are at 36km resolution. Therefore, the default is to use a 1x1 array of model cells around each monitor. This is described in more detail in the Using Model Data section of the Visibility Analysis: Details chapter.

When your window looks like the window above, click **Next**. This brings up the visibility Filtering window.

## 8.4 Step 4. Filtering

The **Filtering** window has two sets of functions. The first involves identifying the years of monitor and model data that you want to use. The second involves identifying the particular monitors in these data that you want to include in the analysis. Use the default settings pictured in the screenshot below.

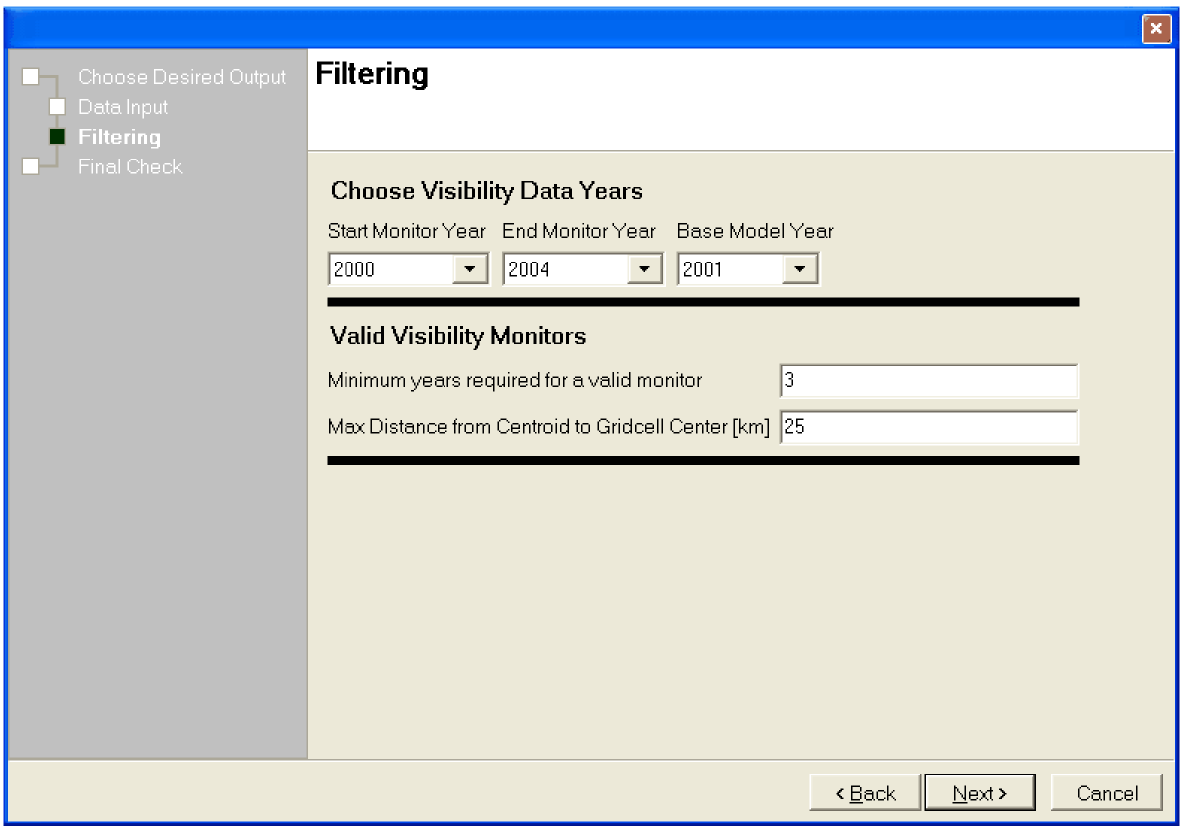
**Choose Visibility Data Years**

- Specify the range of visibility monitor data that you want to use. The default is to use all of the available data: 2000 through 2004. (That is, **Start Monitor Year** set to *2000* and **End Monitor Year** set to *2004*.)
- Choose the **Base Model Year**. This should match the metorological year that is being modeled. It should fall within the range specified by the Start Monitor Year and the End

Monitor Year. The **Base Model Year** for the example dataset is *2001*.

**Valid Visibility Monitors**

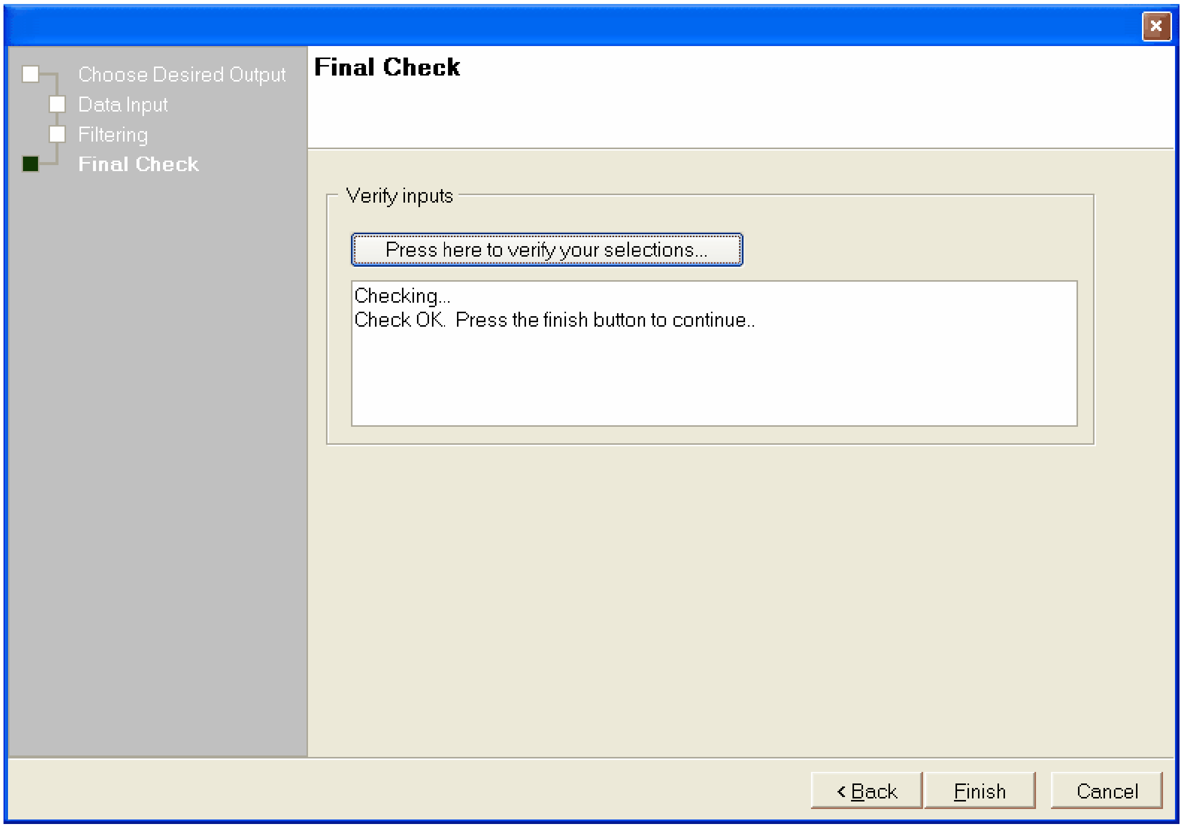
- Identify the monitors that you want to include in the analysis. First, specify the **Minimum years required for a valid monitor**. MATS excludes from the analysis any monitors with fewer than the **Minimum years required for a valid monitor**. The default value is *3* years.
- Specify the **Maximum Distance from Domain [km]**. Monitors that are further than the **Maximum Distance from Domain [km]** are excluded from the analysis. The default value is *25* kilometers (km).




## 8.5 Step 5. Final_Check

The **Final Check** window verifies the choices that you have made. For example, it makes sure that the paths specified to each of the files used in your Configuration are valid.

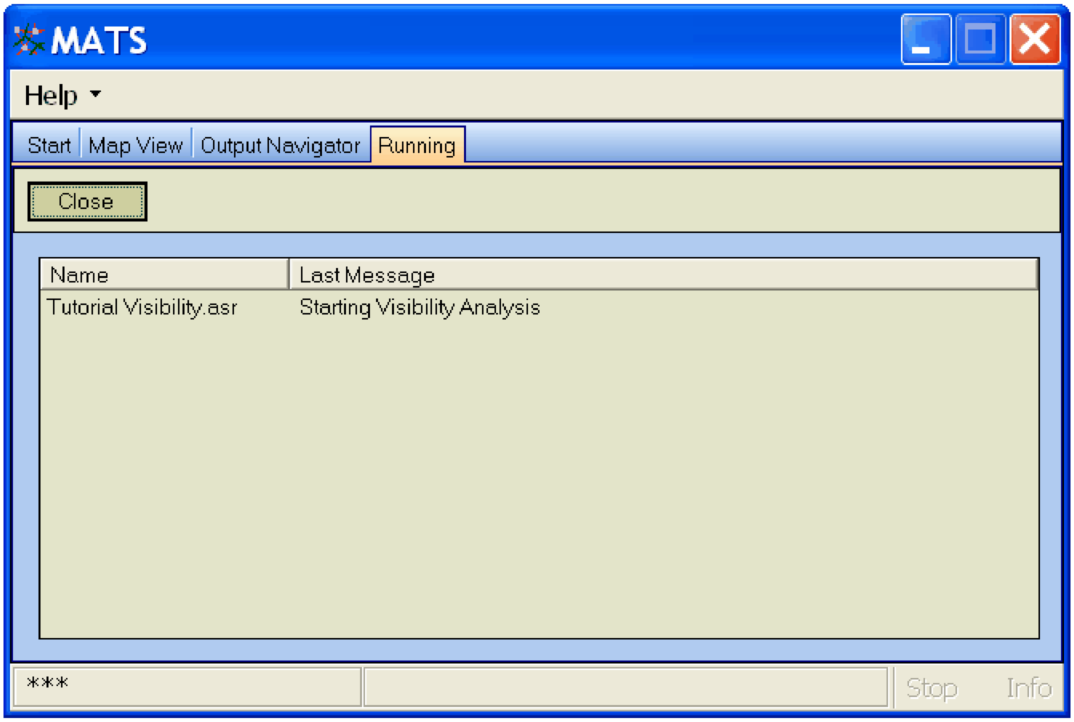
Click on the **Press here to verify selections** button.



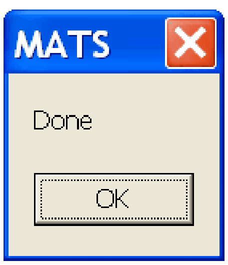

If you encounter any errors, go back to the choices you have previously made by clicking on the appropriate part (**e.g.**, Data Input) of the tree in the left panel, and then make any changes required.

When your window looks like the window above, click **Finish**.

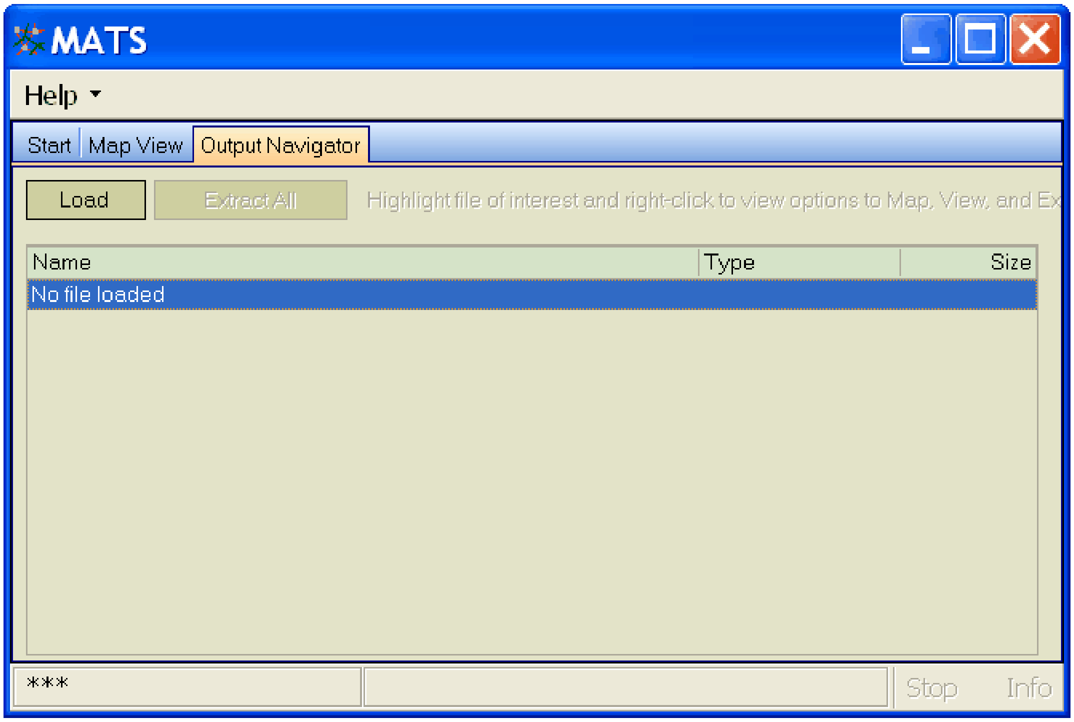
A temporary, new **Running** tab will appear (in addition to the **Start**, Map View and Output Navigator tabs).




Note that MATS is very computation-intensive, so if you try to work with other programs in addition they may run very slowly. When the calculations are complete, a small window indicating the results are **Done** will appear. Click **OK**.



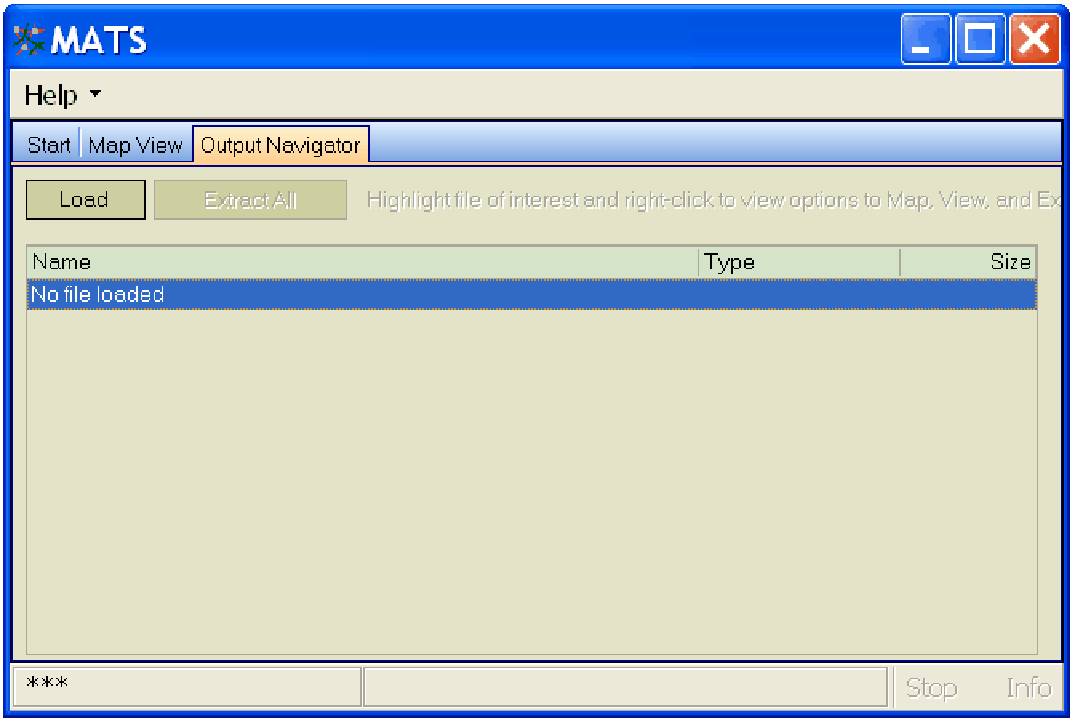

After clicking **OK**, the **Output Navigator** tab will be active. (The **Running** tab will no longer be seen.)



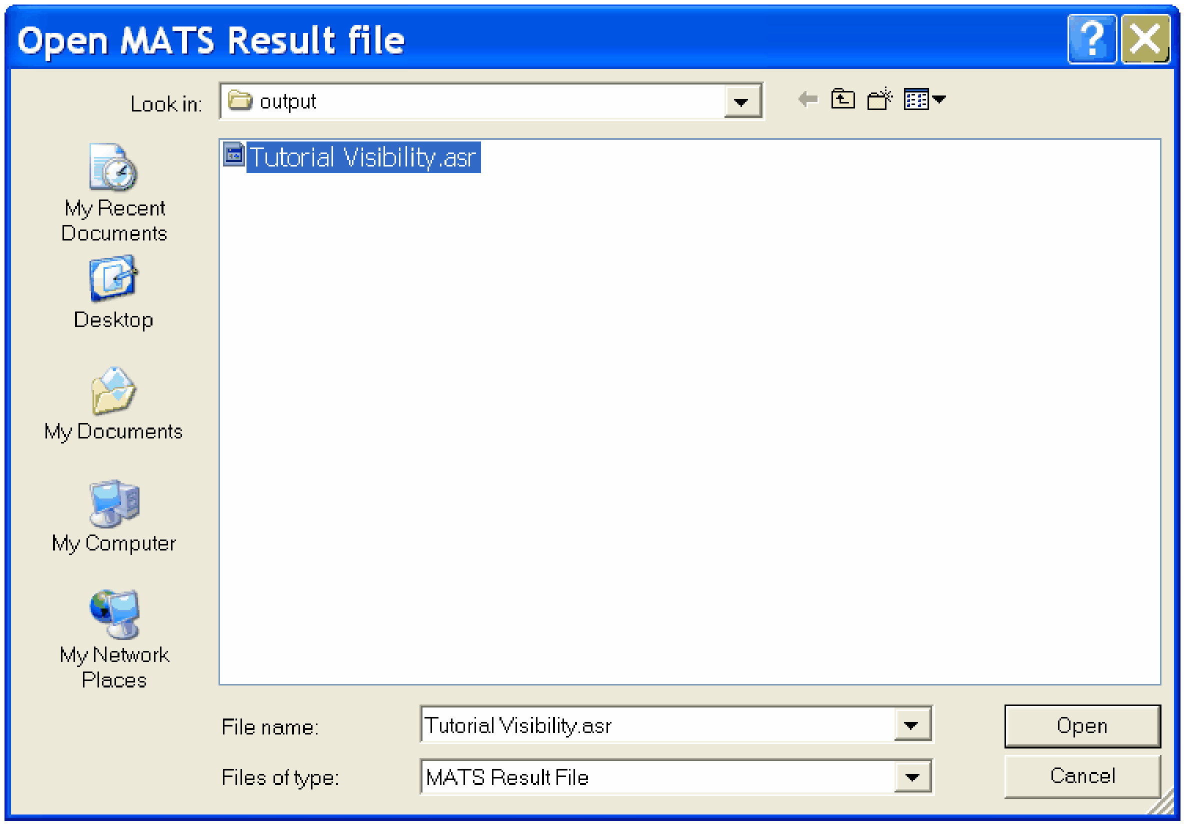

The next step (click here) shows you how to map your results with the **Output Navigator**. For more details on mapping and other aspects of the **Output Navigator**, there is a separate chapter on the Output Navigator.

## 8.6 Step 6. Load and Map Results

The **Output Navigator** tab allows you to look at and export your results in table form or as a map. To start, make sure that the **Output Navigator** tab is active by simply clicking on the tab.




Click on the **Load** button and choose the *Tutorial Visibility.asr* file.

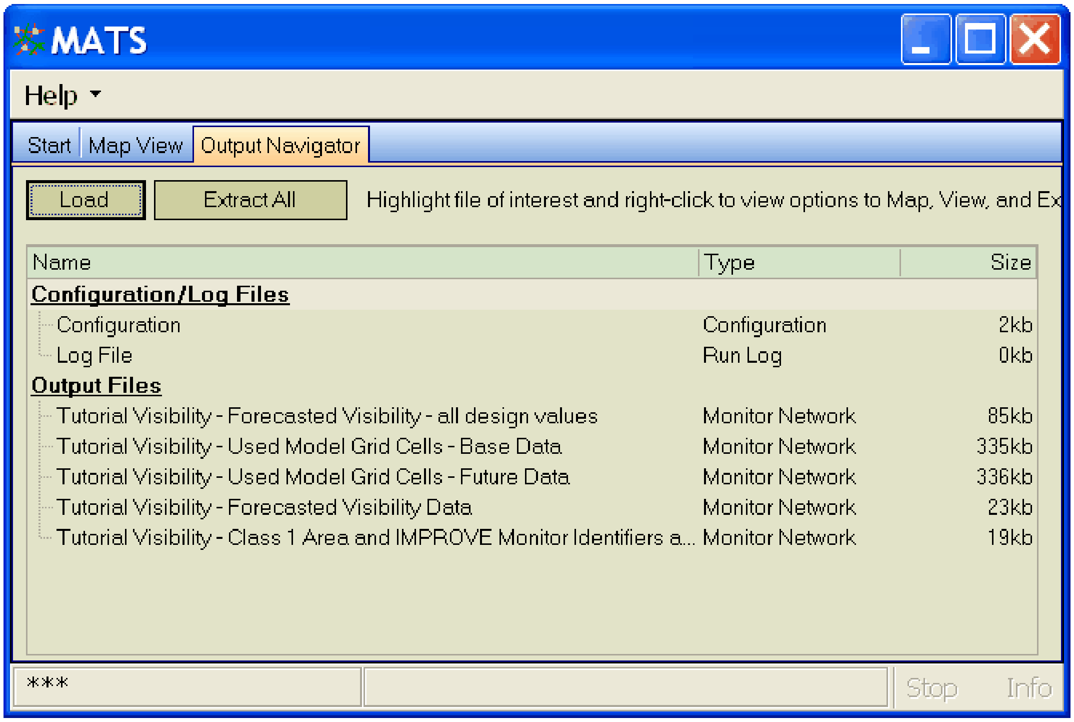



Under **Configuration/Log Files**, you will see two files:

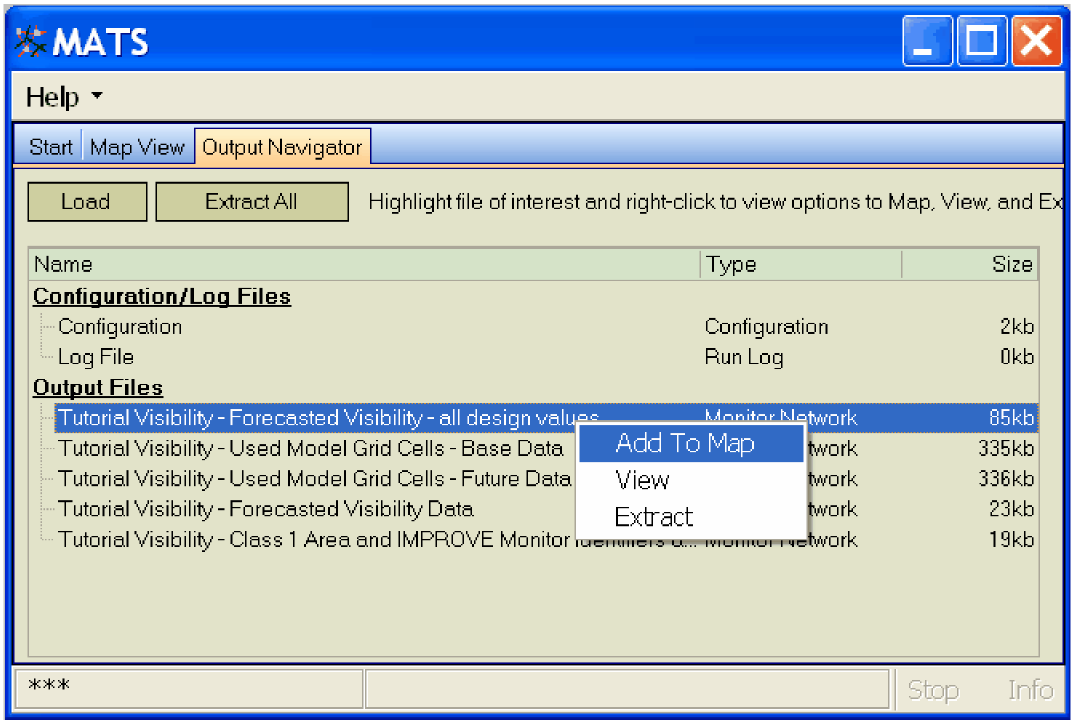
- *Configuration*: keeps track of the assumptions that you have made in your analysis.
- *Log File*: provides information on a variety of technical aspects regarding how a results file (*.ASR) was created.

Under **Output Files** you will see:

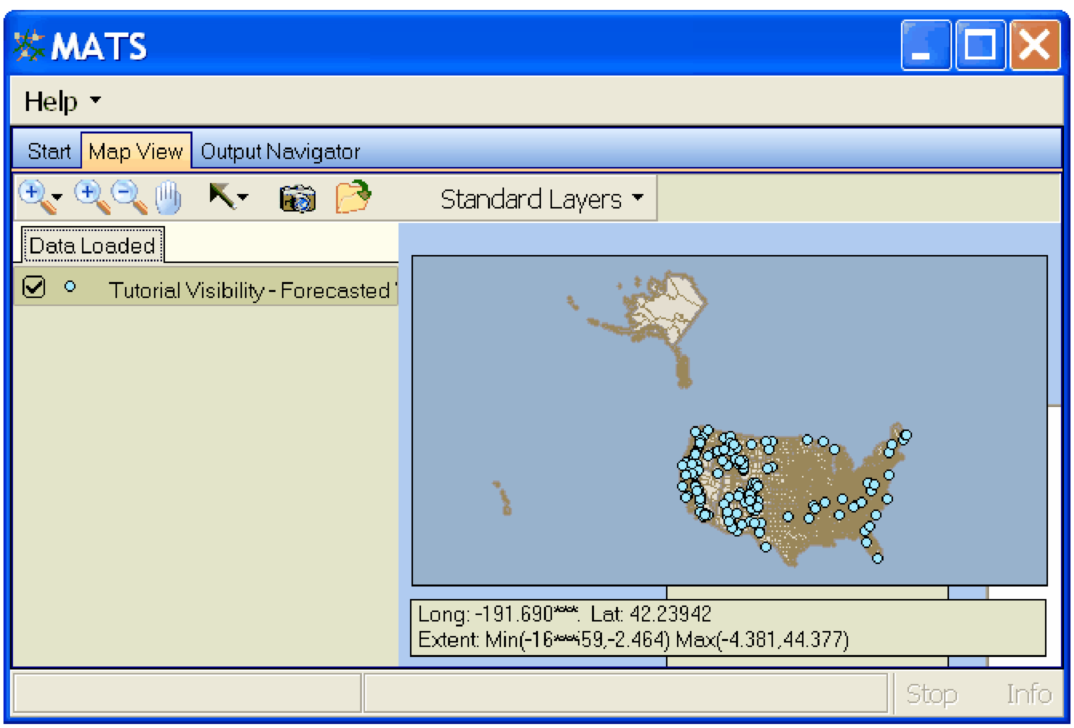
- *Tutorial Visibility - Forecasted Visibility - all design values*: baseline and forecasted visibility levels for the best and worst days for each year of the five year base period.
- *Tutorial Visibility - Used Model Grid Cells - Base Data*: baseline model values for PM species for the grid cells and days used in the RRF calculations.
- *Tutorial Visibility - Used Model Grid Cells - Future Data*: future-year model values for PM species for the grid cells and days used in the RRF calculations.
- *Tutorial Visibility - Forecasted Visibility Data*: baseline and forecasted deciview values for the best and worst days (averaged across up to five years). Also includes species-specific relative response factors for the best and worst days.
- *Tutorial Visibility - Class 1 Area and IMPROVE Monitor Identifiers and Locations*: monitor latitude and longitude.



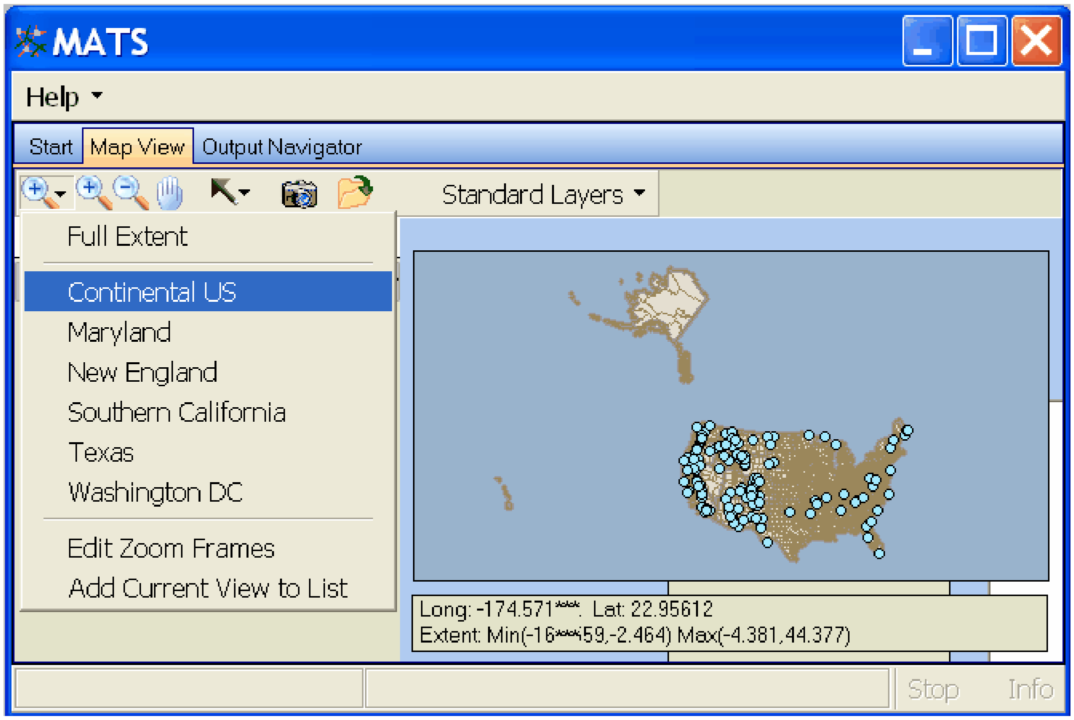

Right-click on the file *Tutorial Visibility - Forecasted Visibility Data*. This gives you three options: *Add to Map*, *View*, and *Extract*. Choose the *Add to Map* option.



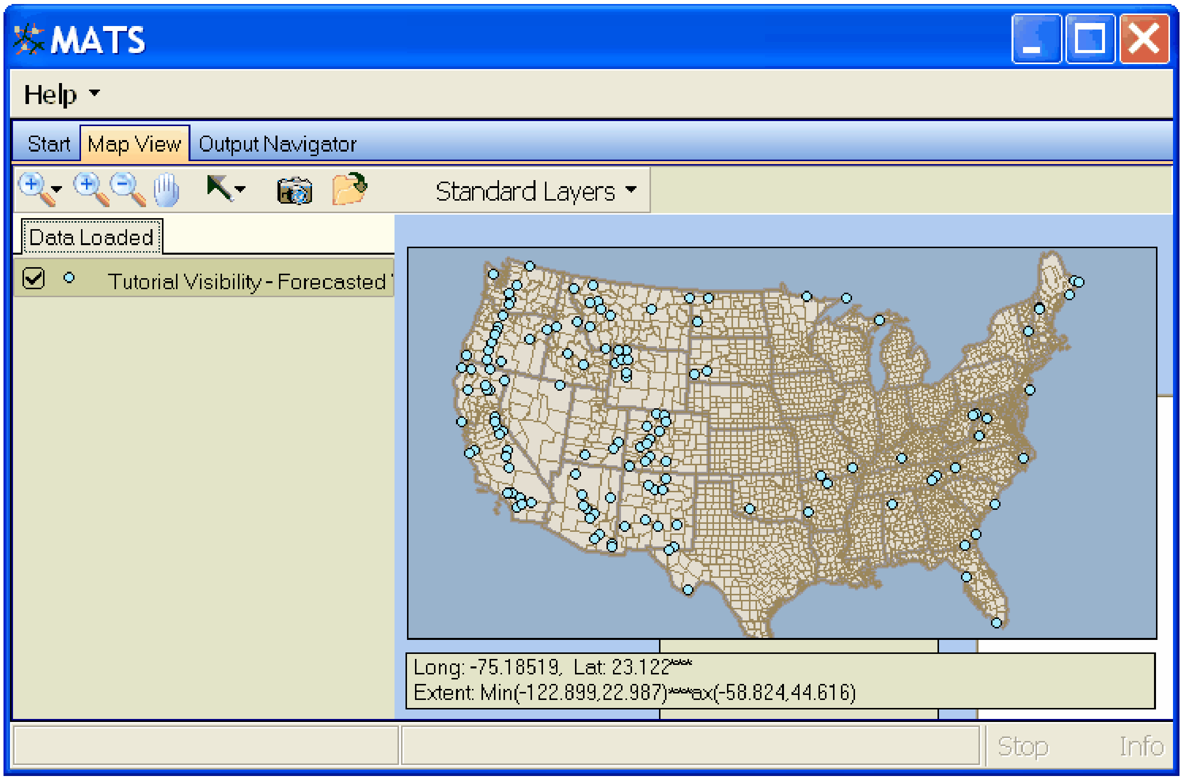

This will bring up the **Map View**.



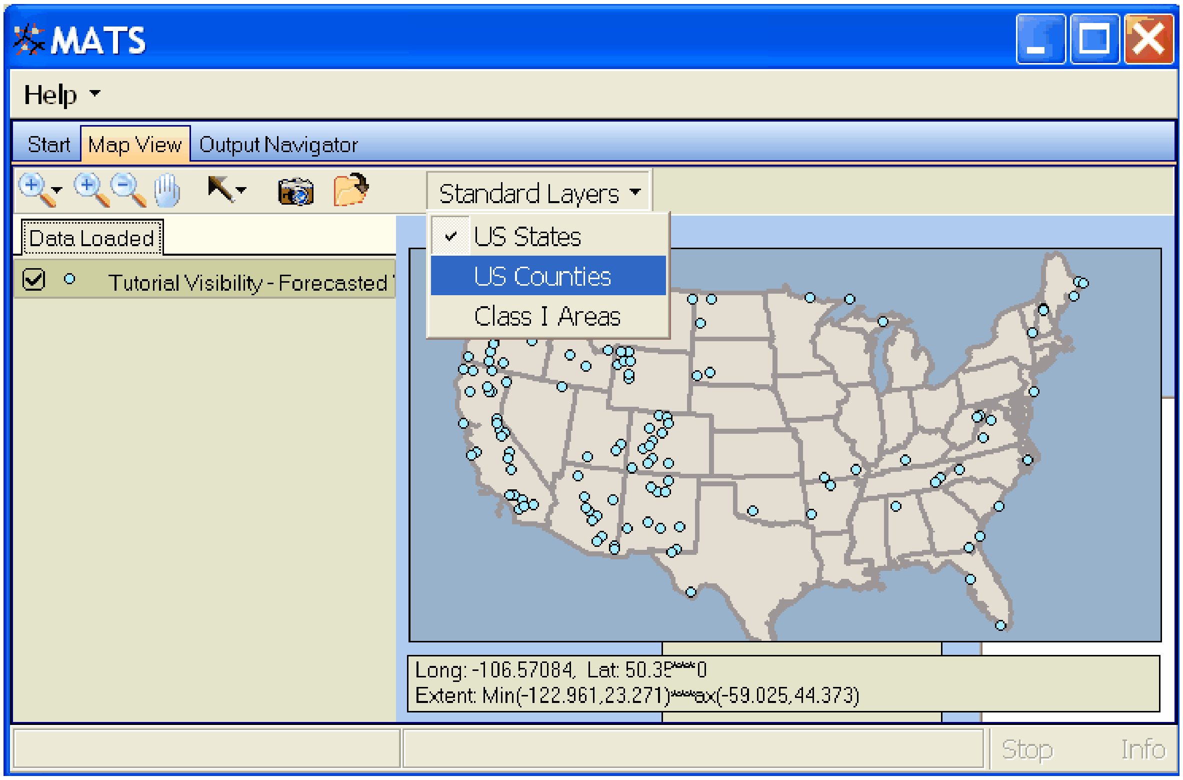
To view an enlarged map, use the **Zoom to an area** Task Bar button on the far left. Choose the *Continental US*.



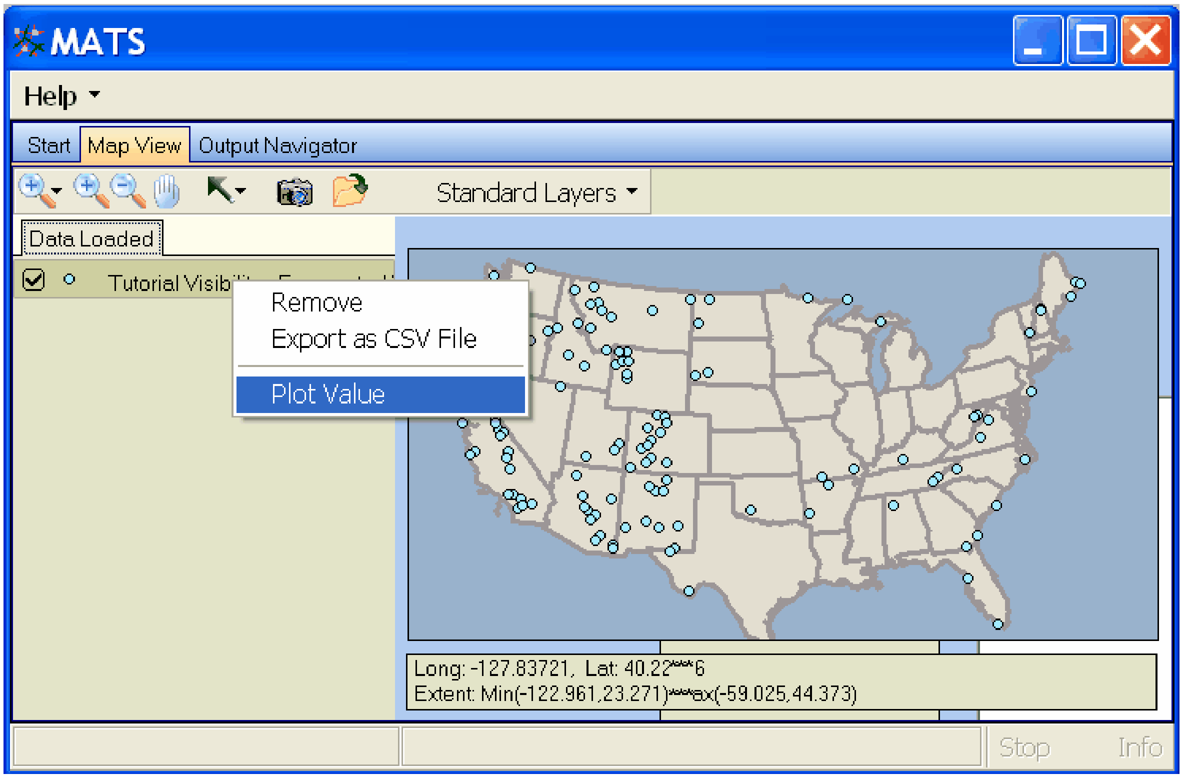

The map will then zoom to the Continental US.



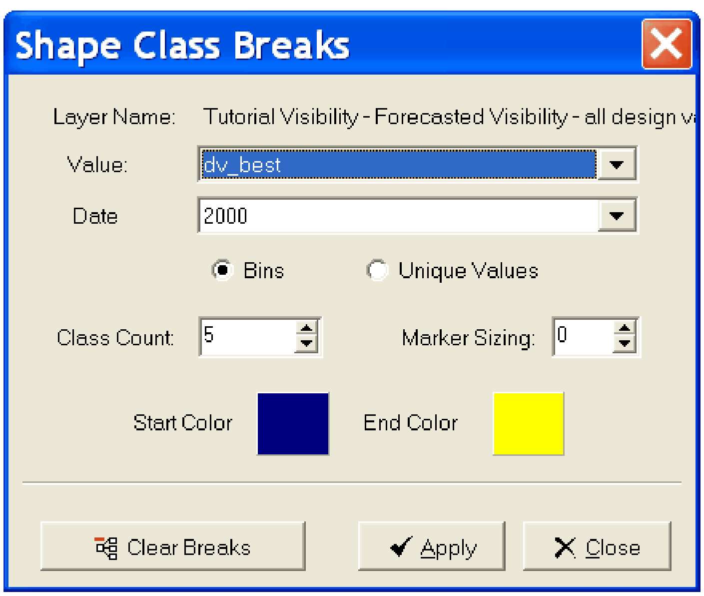

To more easily view the location of monitors in particular states, uncheck *US Counties* using the **Standard Layers** drop down menu on the far right of the Task Bar. Your window should look like the following:



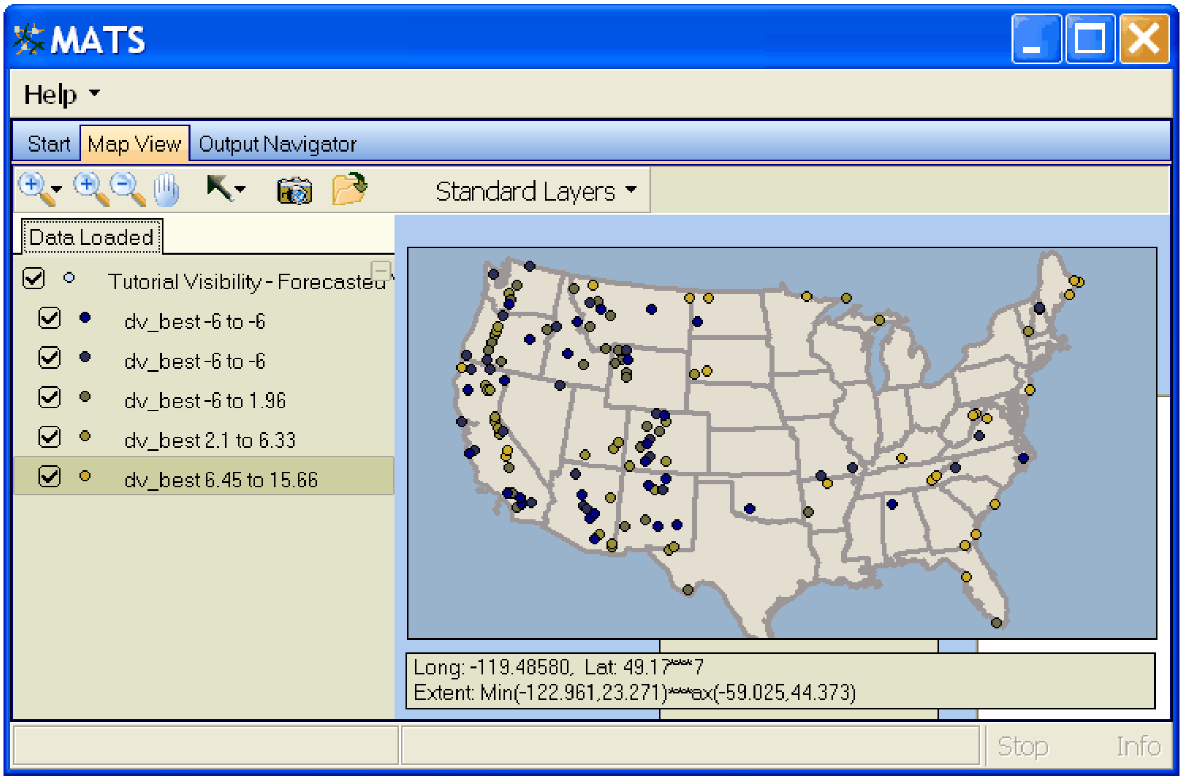

Right click on the "*Tutorial Visibility - Forecasted Visibility Data*" layer in the panel on the left side of the window. Choose the **Plot Value** option.




This will bring up **Shape Class Breaks** window. In the **Value** drop-down list, choose the variable "*dv_best*" -- this is forecasted visibility design value for the best visibility days in 2015. (Note that the **Date** box defaults to the baseline year; in this case *2001*.)



Click **Apply** and then click **Close**. This will bring you back to the **Map View** window.




Examine the other variables:

*dv_worst*: forecasted deciview values for 20% worst days;

*dv_best*: forecasted deciview values for 20% best days

*base_best*: baseline design values for best days;

*base_worst*: baseline design values for worst days;

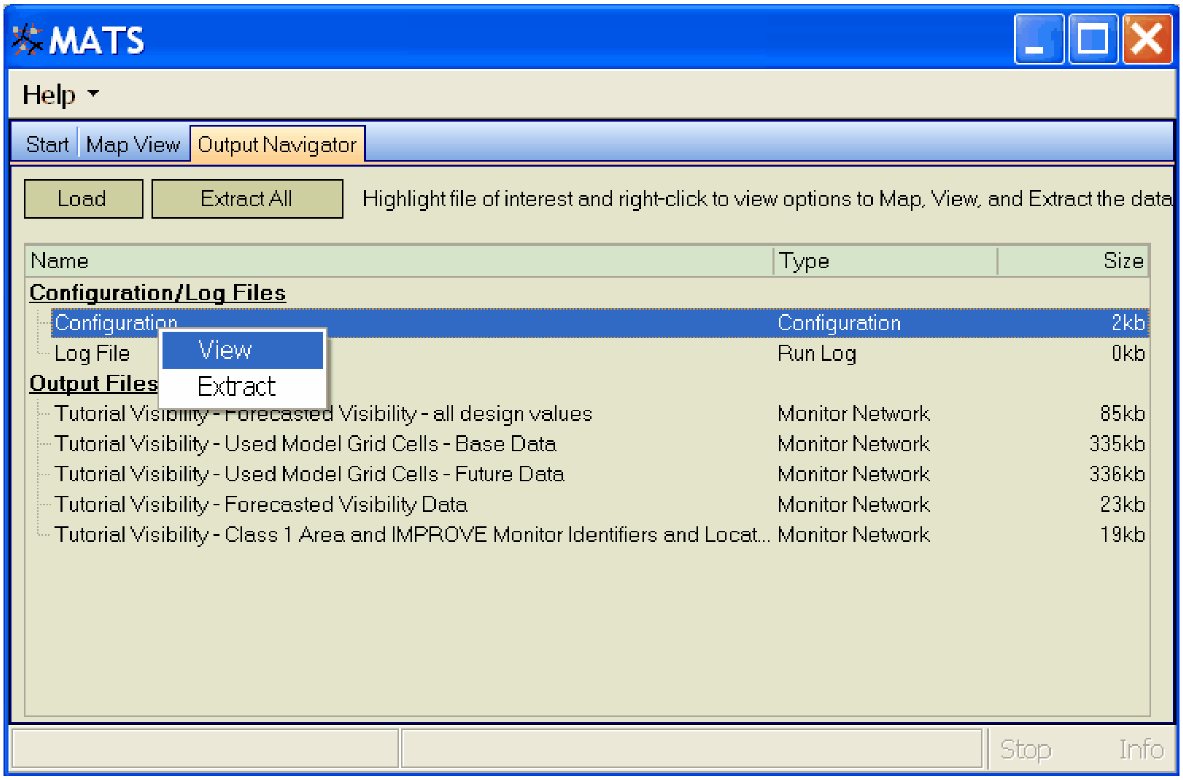
*rrf_b_crustal*, *rrf_b_no3*, *rrf_b_oc*, *rrf_b_ec*, *rrf_b_cm*, and *rrf_b_so4*: relative response factor used to forecast the best visibility days;

*rrf_w_crustal*, *rrf_w_no3*, *rrf_w_oc*, *rrf_w_ec*, *rrf_w_cm*, and *rrf_w_so4*: relative response factor used to forecast the worst visibility days;

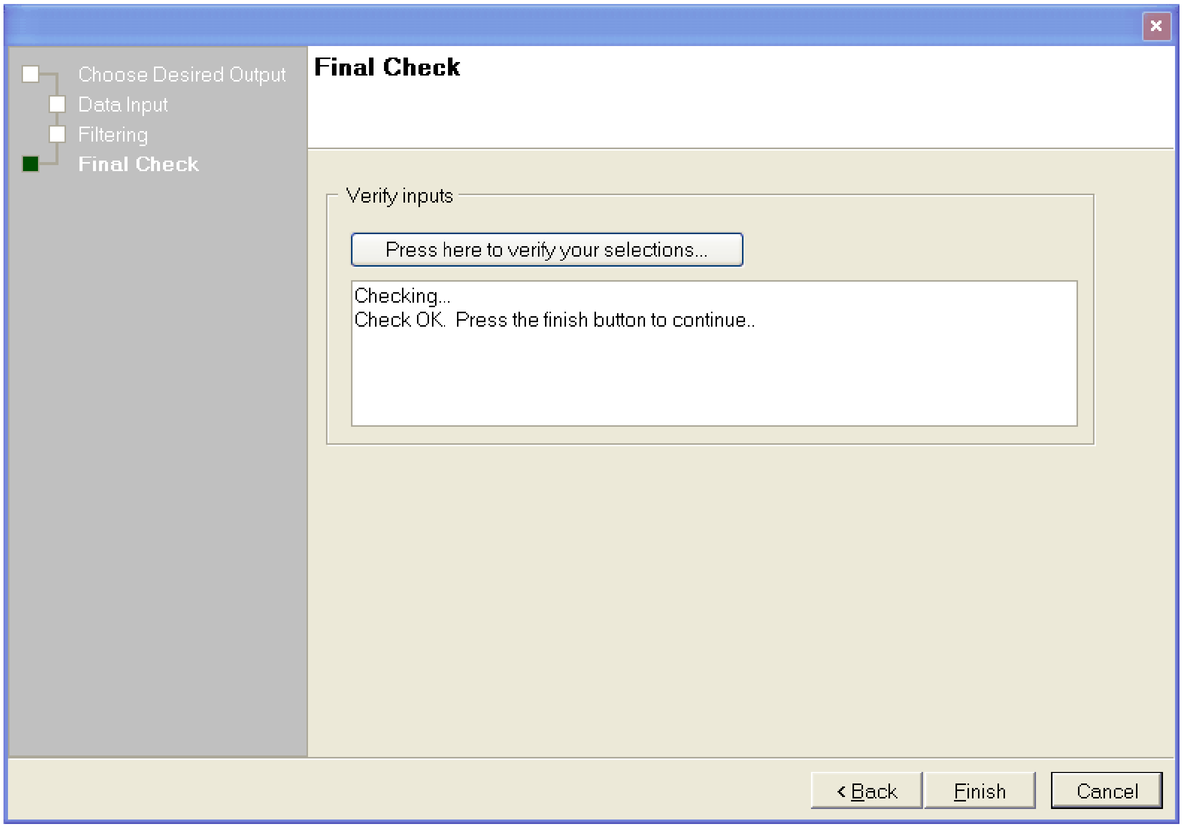
This is just a brief summary of the mapping possibilities available. For more details, there is a separate chapter on the Map View.

## 8.7 Step 7. Working with Configuration File

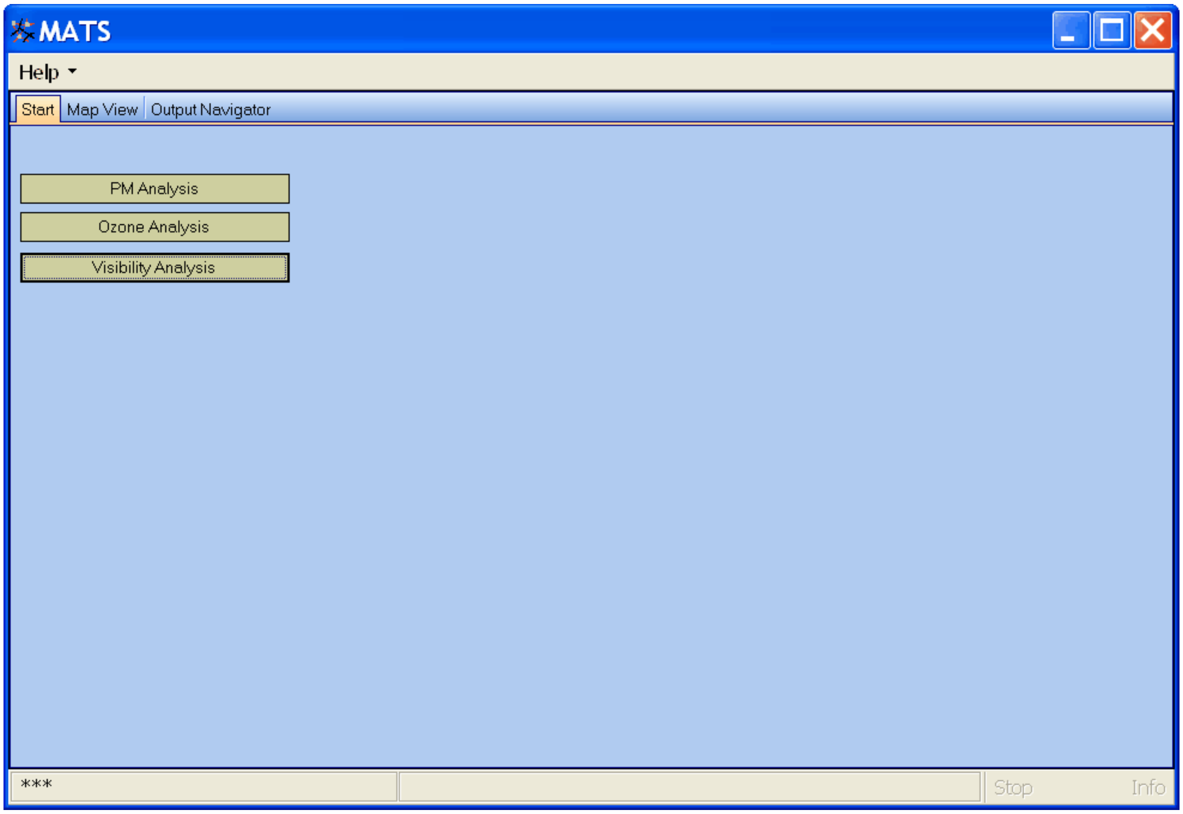
Configurations keep track of the choices that you have made in your analysis. There are two ways that you can access your configuration. First, you can view your configuration using the Output Navigator. Right-click on **Configuration** and choose *View*.



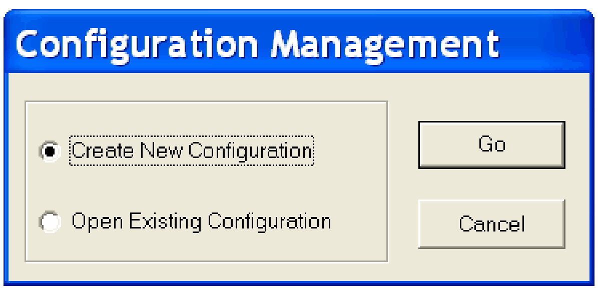

This will take you to the *Tutorial Visibility* configuration that you used to generate your visibility results.



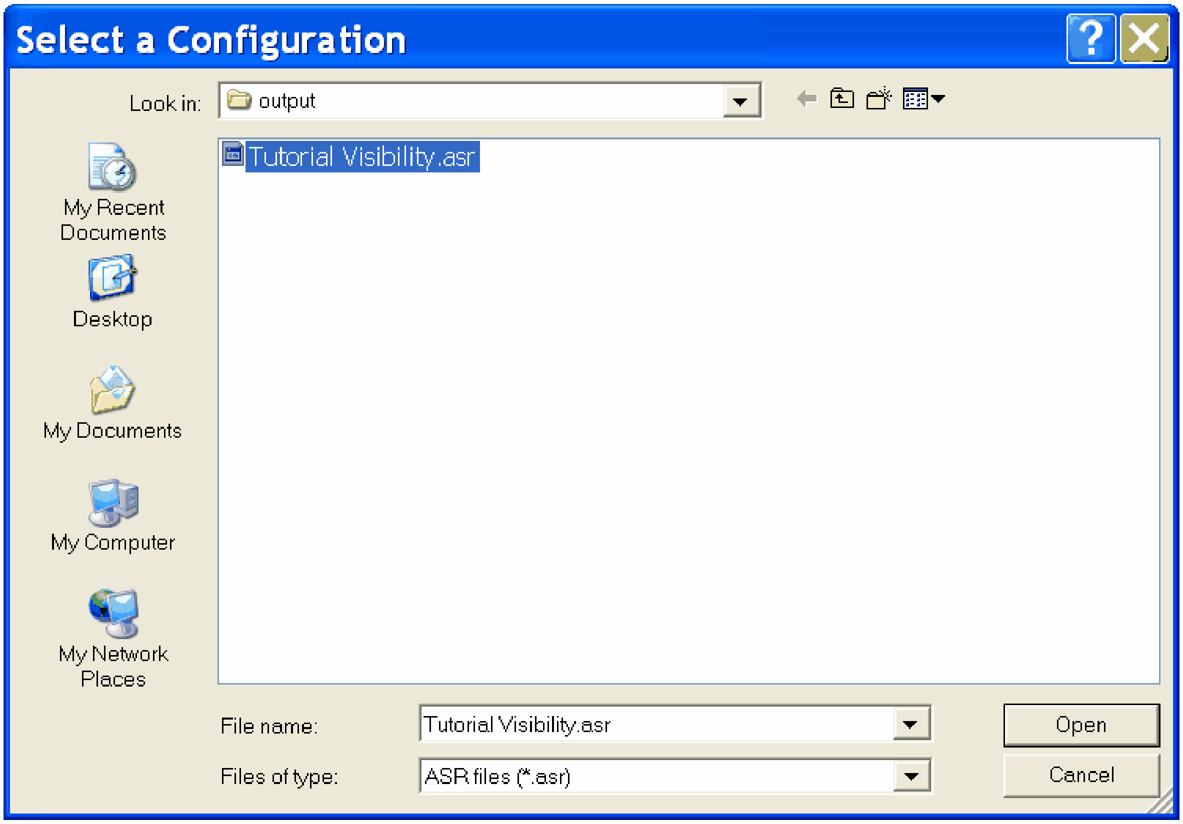

A second way to access your Tutorial Visibility configuration is to go back to the **Start** window.



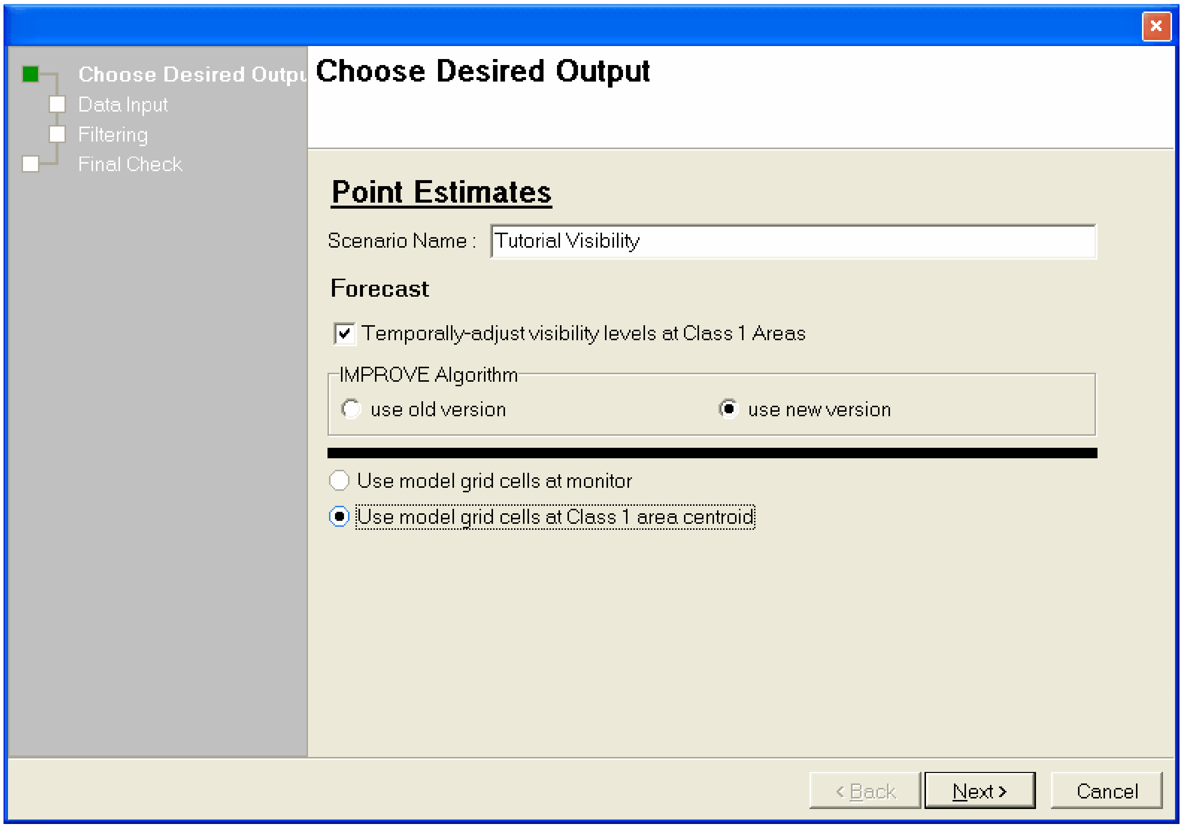

Click on the **Visibility Analysis** button.  This will bring up the **Configuration Management** window.




Choose **Open Existing Configuration** and then click the **Go** button.  This will bring up the **Select a Configuration** window.  Find the *Tutorial Visibility.asr* file that you generated.

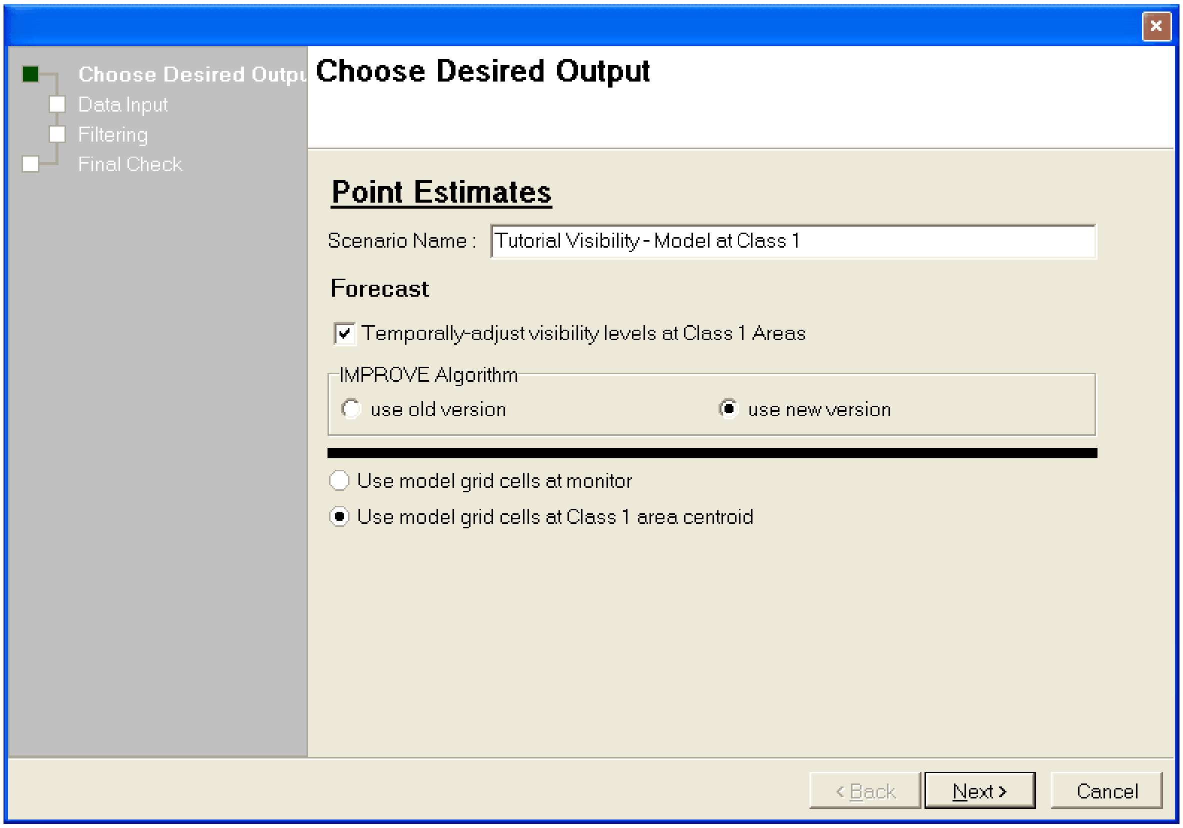



Click **Open** and this will bring you your *Tutorial Visibility* configuration. Choose the **Use model grid cells at Class 1 area centroid** option.




MATS will now calculate RRFs using model data located over the center of each Class 1 area, instead of using model data located over the monitor linked to each Class 1 area.

To reflect this change in your analysis, change the **Scenario Name** box to *Tutorial Visibility - Model at Class 1*.

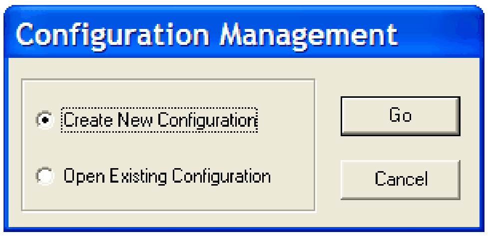



Keep all of the other assumptions the same. At the **Filtering** window, click the **Finish** button. MATS will generate a new set of results and save them in a file called: *Tutorial Visibility - Model at Class 1.asr*. You can then view and map your results in the same way as with other results files.

# 9 Visibility Analysis: Details

MATS can calculate baseline and future-year visibility levels for the best and worst days for Class I Areas -- these estimates are referred to as *Point Estimates*, as they refer to particular locations. MATS gives you several options for how to generate these estimates, and keeps track of the choices you make with a Configuration.

When you begin the process of generating visibility estimates, MATS provides an option to start a new Configuration or to open an existing Configuration.




Select your option and then click **Go**.

MATS will then step you through a series of windows with choices for your analysis.

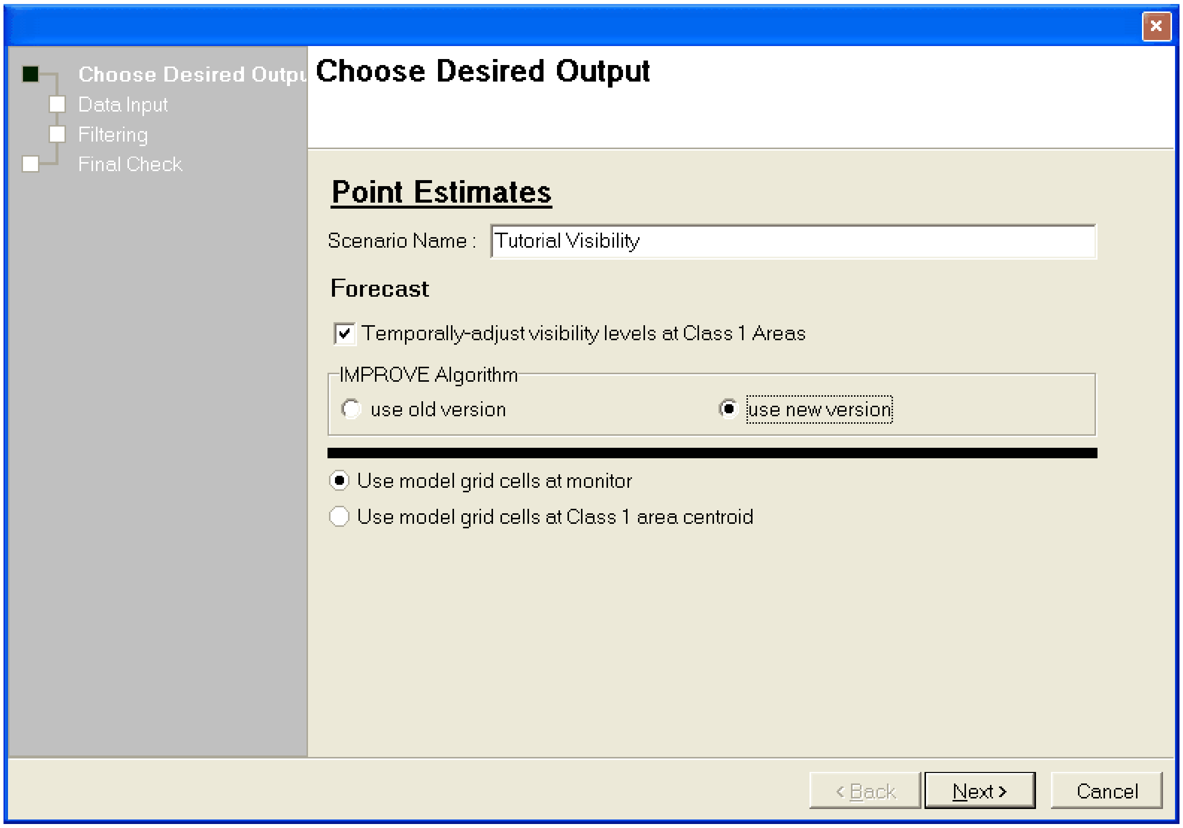
- Choose Desired Output. Choose whether you want to calculate *Point Estimates* at IMPROVE monitors or at Class I Area centroids and whether to use the old or new version of the IMPROVE visibility equation.
- Data Input**.** Specify the air modeling and monitoring data that you want to use. Specify which model grid cells will be used when calculating RRFs at monitor locations.
- Filtering**.** Choose the years of monitoring data. Identify valid monitors.

MATS comes with a set of default choices and an example set of input files. If desired you can use these defaults and skip to the Final Check window and click the **Finish** button to generate your calculations.

## 9.1 Choose Desired Output

In the **Choose Desired Output** window, you specify the Scenario Name that you would like to use, as well as choices regarding how you would like to calculate future year (forecast) visibility levels for Class I Areas. As discussed in the section on Forecasting Visibility, the forecast calculations have a number of steps. At the end of this section, there is an example of these calculations.

You may use the "old version" or "new version" of the IMPROVE Equation (IMPROVE, 2006), which MATS uses to translate PM levels (measured in ug/m3) to visibility levels (measured in extinction or deciviews). You may also choose between using model data at the monitor or model data at the center of the Class I Area.*




* Monitors assigned to represent a Class I Area are generally close to the Class I Area. However, in some cases, the distance can be substantial. For example, the YELL2 monitor in Wyoming (44.5653 latitude, -110.4002 longitude) is located more than a degree longitude away from the Red Rocks Lake Class I Area (44.64 latitude, -111.78 longitude). By default, MATS uses model data at the monitor.

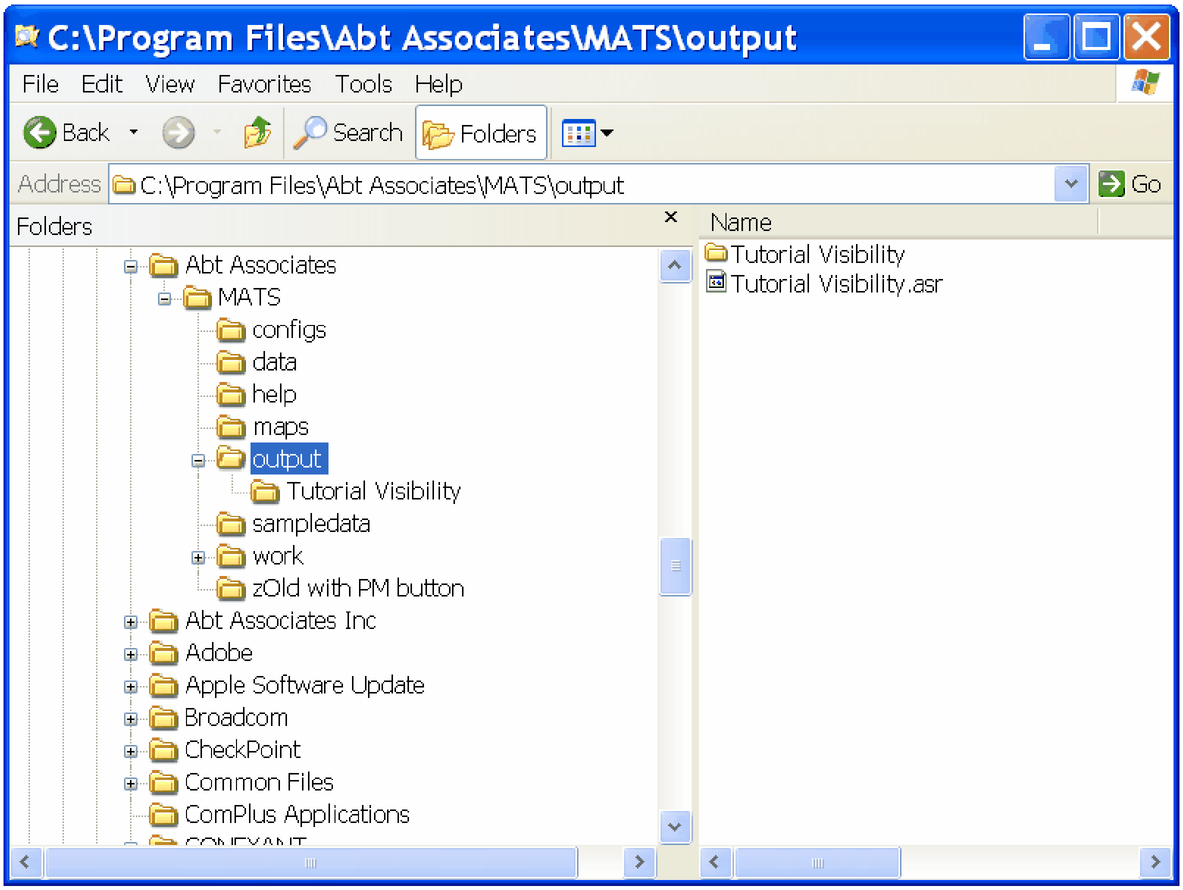
### 9.1.1 Scenario Name

The **Scenario Name** allows you to uniquely identify each analysis that you conduct. It is used in three ways.

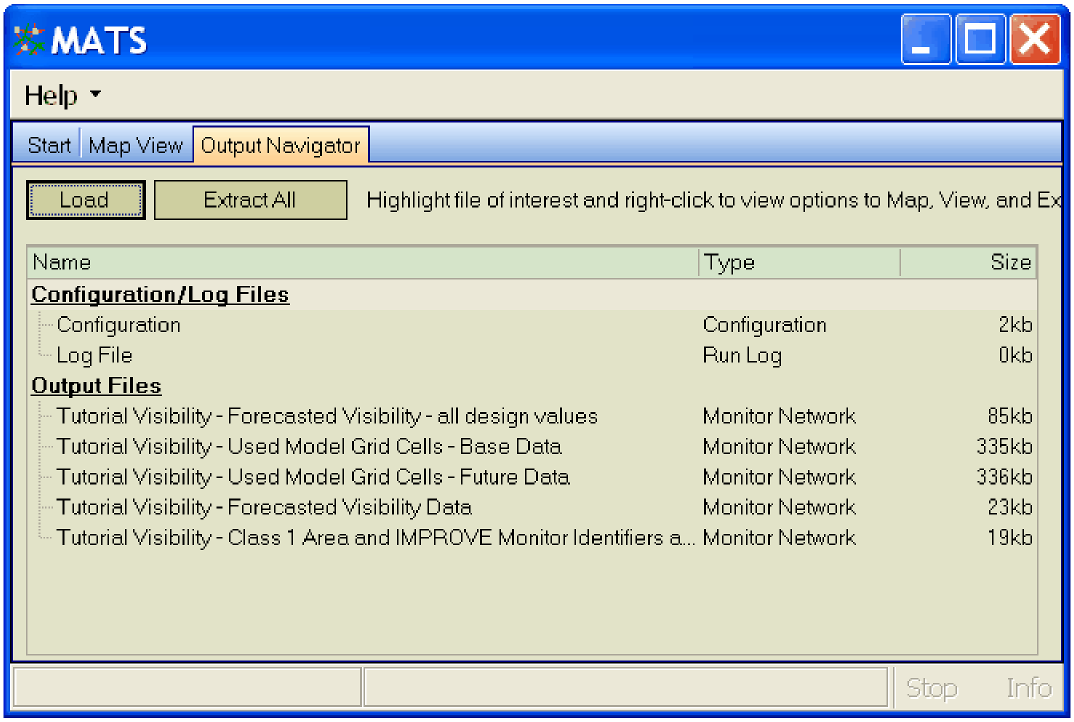
**(1) Results file name**. The results file is given the **Scenario Name** (e.g., *Tutorial Visibility.asr*). Note that the extension (.ASR) is specifically designated just for MATS and can only be used by MATS.

**(2) Organize output**. In the **Output** folder, MATS will generate a folder using the

**Scenario Name**. MATS will use this folder as a default location for files generated with this **Scenario Name**.




**(3) Output file names**. The output files generated will begin with the **Scenario Name**.




### 9.1.2 Forecast Visibility at Class I Areas

MATS provides a forecast of visibility in Class I Areas. The approach used has the following steps:

- **Identify best & worst visibility monitor days in Base Model Year**. Use monitored total extinction data from a user-specified year to identify the 20 percent best and 20 percent worst visibility days at each Class I area. At this stage MATS is using extinction values (measured in inverse megameters). By the end of this series of calculations, MATS will convert these extinction visibility measures to deciviews.

  Note that you specify the particular year, the **Base Model Year**, from the available monitoring data in the Filtering window. MATS labels the year of monitoring data as the **Base Model Year**, because this particular year of monitor data matches the baseline model data, specified in the Data Input window.

- **Average best & worst baseline model days**. Using baseline speciated model data (specified in the **Data Input** window), average the 20 percent best visibility days and then average the 20 percent worst visibility days at each Class I areas (matched with the ambient data). The model data comes into MATS as speciated values measured in ug/m$^3$. Average these speciated values. When done there will be two averages (one "best" the other "worst") for each species and these averages will be ug/m$^3$.

- **Average best & worst forecast model days**. Calculate these same averages for the forecast model data (specified in the **Data Input** window). That is, identify the same 20 percent best and 20 percent worst visibility days and then average the speciated model data (measured in $ug/m^3$).* When done there will be two averages (one "best" the other "worst") for each species and these averages will be in $ug/m^3$.

- **Calculate RRFs**. Use the speciated (best & worst) averages from the baseline and forecast model data to calculate two RRFs for each species. That is, there will be one RRF for the 20 percent best visibility days and another for the 20 percent worst visibility days at each Class I area. The "best" RRF is simply the ratio of the baseline "best" average (measured in $ug/m^3$) to the control scenario "best" average (measured in $ug/m^3$). The "worst" RRF is calculated in an analogous way. An RRF is unitless and there are two for each species.

- **Identify best & worst visibility days in other monitored years.** Using monitored total extinction, identify the 20 percent best visibility days and the 20 percent worst visibility days from the other available years of monitoring data. The default in MATS is that there should be at least three valid years and one of those years should be the base modeling year (the base meteorological year). (Monitor validity is discussed further in the Valid Visibility Monitors section.)

  Note that the 20 percent best days will occur on a different set of days for each year; similarly, the 20 percent worst days will occur on a different set of days for each year.

- **Multiply RRF with speciated monitor data from each year**. Multiply the species-specific "best" RRF (unitless) with the "best" daily speciated monitor values (measured in $ug/m^3$) from each of the available years. Do analogous calculations for the worst days. When done, there will the original (baseline) monitor values and an analogous set of forecast values (equal to the baseline times the RRF).

  Note that the RRF is based on best/worst days identified from the **Base Model Year**. This same "**Base Model Year**" RRF is used with all of the valid monitor years. For example, if the Base Model Year were 2001, then the RRF developed from 2001 modeling data will be applied to all valid data in the five year ambient base period.

- **Convert $ug/m^3$ values to daily extinction values and sum to get total extinction**. For each day in each valid monitor year (for both the baseline and forecast), use either the New IMPROVE equation or the Old IMPROVE equation to convert $ug/m^3$ values to get daily total extinction (measured in inverse megameters). After this calculation there will be a set of total extinction values for the best and worst visibility days in each valid year for both the baseline and the forecast.

- **Convert extinction to deciviews**. For each valid year in both the baseline and forecast, convert the best & worst daily averages from extinction (inverse megameters) to deciviews (unitless). The formula for this conversion is as follows: Deciviews = 10*ln (extinction/10)

- **Average daily best and worst days**. For each valid year, average the daily deciview values from the 20 percent best visibility days and calculate the same average for the 20 percent worst visibility days. There will be up to five "best" averages and "worst" total visibility measures (measured in deciviews) for both the baseline and the forecast.

- **Calculate final average**. Average the valid best/worst yearly visibility measures. When done there will be one "best" value and one "worst" value, measured in deciviews (unitless), for both the baseline and forecast.

---

* The future days are the same as the base year days. The identification of the 20 percent best and worst is solely based on the base year ambient data.

#### 9.1.2.1 Old IMPROVE Equation

The Old IMPROVE equation is as follows:

bext = 3*f(RH)*AMM_SO4

+ 3*f(RH)*AMM_NO3

+ 4*OMC

+ 10*EC

+ CRUSTAL

+ 0.6*CM

+ RAYLEIGH.

where:

bext = total extinction (measured in inverse megameters)

FRH = term to account for enhancement of light scattering due to hydroscopic growth of suflate and nitrate (unitless)

AMM_SO4 = ammonium sulfate (ug/$m^3$)

AMM_NO3 = ammonium nitrate (ug/$m^3$)

OMC = organic carbon mass (ug/$m^3$) (OC*1.4)

EC = elemental carbon (ug/$m^3$)

CRUSTAL = fine soil (ug/$m^3$)

CM = coarse particulate matter (ug/$m^3$)

RAYLEIGH = Rayleigh scattering. Accounts for natural scattering of light by gases in the atmosphere. Assumed to equal 10 inverse megameters at all locations.

**Example Calculation Old IMPROVE Equation**

The first column "bext" presents the calculated value given the following data.

| bext | _ID | LAT | LONG | DATE | FRH | CRUSTAL | AMM_NO3 | OMC | EC | CM | AMM_SO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 71.04 | ACAD1 | 44.3771 | -68.261 | 20000101 | 3.22 | 0.22 | 1.02 | 2.05 | 1.12 | 2.99 | 3.09 |
| 23.70 | ACAD1 | 44.3771 | -68.261 | 20000105 | 3.22 | 0.12 | 0.11 | 0.38 | 0.07 | 0.89 | 1.01 |
| 34.08 | ACAD1 | 44.3771 | -68.261 | 20000108 | 3.22 | 0.13 | 0.24 | 0.95 | 0.15 | 1.69 | 1.58 |
| 37.86 | ACAD1 | 44.3771 | -68.261 | 20000112 | 3.22 | 0.14 | 0.22 | 0.69 | 0.19 | 4.48 | 1.89 |
| 31.26 | ACAD1 | 44.3771 | -68.261 | 20000115 | 3.22 | 0.16 | 0.19 | 0.72 | 0.19 | 2.65 | 1.33 |
| 39.77 | ACAD1 | 44.3771 | -68.261 | 20000119 | 3.22 | 0.18 | 0.60 | 1.44 | 0.30 | 0.95 | 1.49 |
| 42.24 | ACAD1 | 44.3771 | -68.261 | 20000122 | 3.22 | 0.46 | 0.37 | 0.80 | 0.16 | 15.77 | 1.44 |

#### 9.1.2.2 New IMPROVE Equation

The New IMPROVE Equation has a number of additional terms, in relation to the Old IMPROVE equation. In particular, it takes into account the different effects of small and large sulfate, nitrate, and organic carbon particles. A separate equation defining small and large is given below.

bext = 2.2*$f_s$(RH)*[SMALL_AMM_SO4] + 4.8*$f_l$(RH)*[LARGE_AMM_SO4]

+ 2.4*$f_s$(RH)*[SMALL_AMM_NO3] + 5.1*$f_l$(RH)*[LARGE_AMM_NO3]

+ 2.8*[SMALL_OMC] + 6.1*[LARGE_OMC]

+ 10*EC

+ CRUSTAL

+ 0.6*CM

+ SS_RAYLEIGH

+ 1.7*$f_{ss}$(RH)*SEA_SALT

+ 0.33*NO2.

where:

bext = total extinction (measured in inverse megameters)

$f_s$(RH) = term to account for enhancement of light scattering due to hydroscopic growth of small ammonium nitrate and ammonium sulfate (unitless)

$f_l$(RH) = term to account for enhancement of light scattering due to hydroscopic growth of large ammonium nitrate and ammonium sulfate (unitless)

SMALL_AMM_SO4 = small ammonium sulfate (ug/$m^3$)

LARGE_AMM_SO4 = large ammonium sulfate (ug/$m^3$)

SMALL_AMM_NO3 = small ammonium nitrate (ug/$m^3$)

LARGE_AMM_NO3 = large ammonium nitrate (ug/$m^3$)

SMALL_OMC = small organic carbon mass (ug/$m^3$) (OC*1.8)

LARGE_OMC = large organic carbon mass (ug/m$^3$) (OC*1.8)

EC = elemental carbon (ug/m$^3$)

CRUSTAL = fine soil (ug/m$^3$)

CM = coarse particulate matter (ug/m$^3$)

SS_RAYLEIGH = Site-specific Rayleigh scattering (inverse megameters)

$f_{ss}$(RH) = term to account for enhancement of light scattering due to hydroscopic growth of sea salt (unitless)

SEA_SALT = Sea salt (ug/m$^3$)

NO2 = Nitrogen dioxide levels (parts per billion).  This term is assumed to be zero.

The apportionment of the total concentration of sulfate compounds into the concentrations of the small and large size fractions is accomplished using the following equations:

[Large Sulfate] = [Total Sulfate]/20 ug/m3 x [Total Sulfate], for [Total Sulfate] < 20 ug/m3

[Large Sulfate] = [Total Sulfate], for [Total Sulfate] $\geq$ 20 ug/m3

[Small Sulfate] = [Total Sulfate] - [Large Sulfate]

The same equations are used to apportion total nitrate and total organic mass concentrations into the small and large size fractions.

**Example Calculation New IMPROVE Equation**

The first column "bext" presents the calculated value given the following data.

| bext | _ID | LAT | LONG | DATE | FRH | FSRH | FLRH | FSSRH | SS_RAYLEIGH |
|---|---|---|---|---|---|---|---|---|---|
| 71.52 | ACAD1 | 44.3771 | -68.261 | 20000101 | 3.22 | 3.82 | 2.75 | 3.91 | 12 |
| 24.51 | ACAD1 | 44.3771 | -68.261 | 20000105 | 3.22 | 3.82 | 2.75 | 3.91 | 12 |
| 34.45 | ACAD1 | 44.3771 | -68.261 | 20000108 | 3.22 | 3.82 | 2.75 | 3.91 | 12 |
| 38.10 | ACAD1 | 44.3771 | -68.261 | 20000112 | 3.22 | 3.82 | 2.75 | 3.91 | 12 |
| 35.45 | ACAD1 | 44.3771 | -68.261 | 20000115 | 3.22 | 3.82 | 2.75 | 3.91 | 12 |
| 40.22 | ACAD1 | 44.3771 | -68.261 | 20000119 | 3.22 | 3.82 | 2.75 | 3.91 | 12 |
| 43.92 | ACAD1 | 44.3771 | -68.261 | 20000122 | 3.22 | 3.82 | 2.75 | 3.91 | 12 |

| SEA_SALT | CRUSTAL | AMM_NO3 | OMC | EC | PM10 | CM | AMM_SO4 | LARGE_OMC | SMALL_OMC |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.22 | 1.02 | 2.63 | 1.12 | 11.05 | 2.99 | 3.09 | 0.35 | 2.29 |
| 0 | 0.12 | 0.11 | 0.49 | 0.07 | 2.72 | 0.89 | 1.01 | 0.01 | 0.48 |
| 0 | 0.13 | 0.24 | 1.22 | 0.15 | 4.94 | 1.69 | 1.58 | 0.07 | 1.15 |
| 0 | 0.14 | 0.22 | 0.89 | 0.19 | 7.82 | 4.48 | 1.89 | 0.04 | 0.85 |
| 0.55116 | 0.16 | 0.19 | 0.93 | 0.19 | 5.53 | 2.65 | 1.33 | 0.04 | 0.89 |
| 0 | 0.18 | 0.60 | 1.85 | 0.30 | 5.03 | 0.95 | 1.49 | 0.17 | 1.68 |
| 0.192906 | 0.46 | 0.37 | 1.02 | 0.16 | 19.56 | 15.77 | 1.44 | 0.05 | 0.97 |

| LARGE_AMM_SO4 | SMALL_AMM_SO4 | LARGE_AMM_NO3 | SMALL_AMM_NO3 |
|---|---|---|---|
| 0.48 | 2.61 | 0.05 | 0.97 |
| 0.05 | 0.96 | 0.00 | 0.11 |
| 0.13 | 1.46 | 0.00 | 0.24 |
| 0.18 | 1.71 | 0.00 | 0.22 |
| 0.09 | 1.24 | 0.00 | 0.19 |
| 0.11 | 1.38 | 0.02 | 0.59 |
| 0.10 | 1.34 | 0.01 | 0.37 |

#### 9.1.2.3 Choose Model Grid Cell

The model data are used to calculate an RRF for each species for both the best and worst visibility days. The RRF is the ratio of future-year modeled visibility levels over baseline modeled visibility levels. When forecasting visibility, MATS allows you to choose whether the RRF will be calculated with model data from the grid cell containing the monitor or the centroid of the Class I Area.

The representative IMPROVE monitor assignments are taken from Appendix A, Table A-2 of "Guidance for Tracking Progress Under the Regional Haze Rule" http://www.epa.gov/ttn/oarpg/t1/memoranda/rh_tpurhr_gd.pdf. Monitors assigned to represent a Class I Area are generally close to the Class I Area. However, in some cases, this distance can be substantial. For example, the YELL2 monitor in Wyoming (44.5653 latitude, -110.4002 longitude) is located more than a degree longitude away from the Red Rocks Lake Class I Area (44.64 latitude, -111.78 longitude). By default, MATS uses model data at the monitor.

### 9.1.3 Output Variable Description

MATS generates five output files:

- Visibility forecast (average of design values). (Up to) five year average of forecasted and base-year average visibility. When you have specified the option **Use model grid cells at monitor**, name of this file is "Forecasted Visibility Data.csv" with the Scenario Name appended at the beginning (e.g., "Tutorial Visibility - Forecasted Visibility Data.csv"). When you have specified the option **Use model grid cells at Class 1 area centroid**, name of this file changes to "Forecasted Visibility Data for Class 1 Areas.csv" plus the Scenario Name (e.g., "Example Visibility - Forecasted Visibility Data for Class 1 Areas. csv").

- Visibility forecast (all design values). Forecasted and base-year values for individual years. (The forecast is based on The name of this file is "Forecasted Visibility - all design values.csv" plus the Scenario Name (e.g., "Tutorial Visibility - Forecasted Visibility - all design values.csv").
- Class I areas and the monitors. Contains a list of all of the Class I areas and the monitors assigned to each. The name of this file is "Class 1 Area and IMPROVE Monitor Identifiers and Locations.csv" plus the Scenario Name (e.g., "Tutorial Visibility - Class 1 Area and IMPROVE Monitor Identifiers and Locations.csv").
- Base-year model data used. The name of this file is: "Used Model Grid Cells - Base Data.csv" plus the Scenario Name (e.g., "Tutorial Visibility - Used Model Grid Cells - Base Data.csv"). This file contains the base year model values for PM species for the grid cells and days used in the RRF calculations.
- Future-year model data used. The format for this file is the same as for the base-year. The name of this file is: "Used Model Grid Cells - Future Data.csv" plus the Scenario Name (e.g., "Tutorial Visibility - Used Model Grid Cells - Future Data.csv"). This file contains the future year model values for PM species for the grid cells and days used in the RRF calculations.

The following sub-sections describe the variables in each file.

#### 9.1.3.1 Forecasted Visibility Data.csv

An example of this output file is as follows (with variable definitions in the table below). Note that the output data includes a large number of variables, so in the sample output below we have divided the variables into two blocks. In a file actually generated by MATS, these two blocks would be combined.

Note also that the variables output by MATS depend on whether you have specified using model data at the monitor or model data at the center of the Class I Area. This is detailed in the description table below.

**Tutorial Visibility - Forecasted Visibility Data.csv**

| Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| _id | _type | date | dv_best | dv_worst | base_best | base_worst | rrf_b_crustal | rrf_b_no3 | rrf_b_oc | rrf_b_ec | rrf_b_cm | rrf_b_so4 |
| ACAD | | 2001 | 7.96 | 19.81 | 8.77 | 22.89 | 1.064 | 0.653 | 0.963 | 0.745 | 1.573 | 0.939 |
| AGTI | | 2001 | 9.31 | 22.38 | 9.58 | 23.5 | 1.097 | 1.076 | 0.968 | 0.698 | 1.28 | 1.091 |
| ALLA | | 2001 | 4.67 | 15.18 | 5.5 | 17.84 | 1.02 | 0.997 | 0.978 | 0.573 | 1.417 | 0.69 |
| ANAC | | 2001 | 2.14 | 10.84 | 2.58 | 13.41 | 1.074 | 1.047 | 0.978 | 0.824 | 1.273 | 0.943 |
| ARCH | | 2001 | 3.21 | 9.51 | 3.75 | 11.24 | 1.105 | 0.878 | 0.988 | 0.85 | 1.179 | 1.001 |

| rrf_w_crustal | rrf_w_n03 | rrf_w_oc | rrf_w_ec | rrf_w_cm | rrf_w_s04 | monitor_gridcell | gridcell_lat | gridcell_long | monitor_lat | monitor_long |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.996 | 0.875 | 0.913 | 0.632 | 1.292 | 0.751 | 82139 | 44.3878 | -68.1720 | 44.3770 | -68.2610 |
| 1.123 | 0.87 | 0.987 | 0.763 | 1.293 | 1.055 | 44025 | 33.4216 | -117.1566 | 33.4640 | -116.9700 |
| 1.1 | 0.817 | 0.964 | 0.656 | 1.104 | 0.916 | 88026 | 47.3626 | -121.2959 | 47.4220 | -121.4300 |
| 1.077 | 0.856 | 0.972 | 0.92 | 1.15 | 0.904 | 80040 | 45.8653 | -114.0405 | 45.8600 | -114.0000 |
| 1.063 | 0.927 | 0.984 | 0.858 | 1.128 | 0.961 | 56046 | 38.4896 | -109.7266 | 38.4590 | -109.8200 |

| **Variable** | **Description** |
|---|---|
| _id | Site ID |
| _type | Leave blank |
| date | Meteorological modeling year (used to identify the 20% best and worst days from the ambient data) |
| dv_best | Forecasted (future year) best visibility [up to five year average] (in deciviews) |
| dv_worst | Forecasted (future year) worst visibility [up to five year average] |
| base_best | Base-year best visibility [up to five year average] |
| base_worst | Base-year worst visibility [up to five year average] |
| rrf_b_crustal | Relative response factor (RRF) for crustal matter on the best visibility days |
| rrf_b_no3 | RRF for nitrate on the best visibility days |
| rrf_b_oc | RRF for organic mass on the best visibility days |
| rrf_b_ec | RRF for elemental carbon on the best visibility days |
| rrf_b_cm | RRF for coarse matter (PM10 minus PM2.5) on the best visibility days |
| rrf_b_so4 | RRF for sulfate on the best visibility days |
| rrf_w_crustal | RRF for crustal matter on the worst visibility days |
| rrf_w_no3 | RRF for nitrate on the worst visibility days |
| rrf_w_oc | RRF for organic mass on the worst visibility days |
| rrf_w_ec | RRF for elemental carbon on the worst visibility days |
| rrf_w_cm | RRF for coarse matter (PM10 minus PM2.5) on the worst visibility days |
| rrf_w_so4 | RRF for sulfate on the worst visibility days |
| monitor_gridcell | Identifier for grid cell closest to monitor. (This variable only appears if you specified the **Use model grid cell at monitor** option.) |
| class_i_gridcell | Identifier for grid cell closest to Class 1 area. (This variable only appears if you specified the **Use model grid cell at Class 1 area centroid** option.) |
| gridcell_lat | Centroid latitude in decimal degrees of grid cell used in calculation. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| gridcell_long | Centroid longitude in decimal degrees of grid cell used in calculation. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| monitor_lat | Monitor latitude. (This variable only appears if you specified the **Use model grid cell at monitor** option.) |
| class_i_lat | Class 1 area centroid latitude. (This variable only appears if you specified the **Use model grid cell at Class 1 area centroid** option.) |
| monitor_long | Monitor longitude. (This variable only appears if you specified the **Use model grid cell at monitor** option.) |
| class_i_long | Class 1 area centroid longitude. (This variable only appears if you specified the **Use model grid cell at Class 1 area centroid** option.) |

#### 9.1.3.2 Forecasted Visibility - all design values.csv

An example of this output file is as follows (with variable definitions in the table below).

Note that the variables output by MATS depend on whether you have specified [using model data]() at the monitor or model data at the center of the Class I Area.  This is detailed in the description table below.

**Tutorial Visibility - Forecasted Visibility - all design values.csv**

Year

| _id | _type | date | dv_best | dv_worst | base_best | base_worst | monitor_gridcell | gridcell_lat | gridcell_long | monitor_lat | monitor_long |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ACAD | | 2000 | 7.95 | 18.82 | 8.89 | 21.64 | 82139 | 44.3878 | -68.1720 | 44.3770 | -68.2610 |
| ACAD | | 2001 | 8.31 | 19.99 | 8.87 | 23.28 | 82139 | 44.3878 | -68.1720 | 44.3770 | -68.2610 |
| ACAD | | 2002 | 8.01 | 20.84 | 8.77 | 23.91 | 82139 | 44.3878 | -68.1720 | 44.3770 | -68.2610 |
| ACAD | | 2003 | 7.98 | 20.38 | 8.77 | 23.65 | 82139 | 44.3878 | -68.1720 | 44.3770 | -68.2610 |
| ACAD | | 2004 | 7.56 | 19.03 | 8.56 | 21.98 | 82139 | 44.3878 | -68.1720 | 44.3770 | -68.2610 |
| AGTI | | 2000 | -10 | -10 | -10 | -10 | 44025 | 33.4216 | -117.1566 | 33.4640 | -116.9700 |
| AGTI | | 2001 | 9.56 | 21.85 | 10.17 | 22.92 | 44025 | 33.4216 | -117.1566 | 33.4640 | -116.9700 |

| Variable | Description |
|---|---|
| _id | Site ID |
| _type | Leave blank |
| date | Base year of monitoring data |
| dv_best | Forecasted (future year) best visibility (in deciviews) |
| dv_worst | Forecasted (future year) worst visibility |
| base_best | Base-year best visibility |
| base_worst | Base-year worst visibility |
| monitor_gridcell | Identifier for grid cell closest to monitor.  (This variable only appears if you specified the **Use model grid cell at monitor** option.) |
| class_i_gridcell | Identifier for grid cell closest to Class 1 area.  (This variable only appears if you specified the **Use model grid cell at Class 1 area centroid** option.) |
| gridcell_lat | Centroid latitude in decimal degrees of grid cell used in calculation. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| gridcell_long | Centroid longitude in decimal degrees of grid cell used in calculation.  Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| monitor_lat | Monitor latitude.  (This variable only appears if you specified the **Use model grid cell at monitor** option.) |
| class_i_lat | Class 1 area centroid latitude.  (This variable only appears if you specified the **Use model grid cell at Class 1 area centroid** option.) |
| monitor_long | Monitor longitude.  (This variable only appears if you specified the **Use model grid cell at monitor** option.) |
| class_i_long | Class 1 area centroid longitude.  (This variable only appears if you specified the **Use model grid cell at Class 1 area centroid** option.) |

### 9.1.3.3 Class 1 Area and IMPROVE Monitor Identifiers and Locations.csv

An example of this output file is as follows (with variable definitions in the table below). Note that the output data includes a number of variables, so in the sample output below we have divided the variables into two blocks. In a file actually generated by MATS, these two blocks would be combined.

**Tutorial Visibility - Class 1 Area and IMPROVE Monitor Identifiers and Locations.csv**

Day

| _id | _type | _class_i_name | class_i_state | class_i_lat | class_i_long | class_i_gridcell | date |
|---|---|---|---|---|---|---|---|
| ACAD | | Acadia NP | ME | 44.35 | -68.24 | -8 | 20000101 |
| AGTI | | Agua Tibia Wilderness | CA | 33.42 | -116.99 | -8 | 20000101 |
| ALLA | | Alpine Lake Wilderness | WA | 47.55 | -121.16 | -8 | 20000101 |
| ANAC | | Anaconda-Pintler Wilderness | MT | 45.95 | -113.5 | -8 | 20000101 |
| ANAD | | Ansel Adams Wilderness (Minarets) | CA | 37.74 | -119.19 | -8 | 20000101 |
| ARCH | | Arches NP | UT | 38.73 | -109.58 | -8 | 20000101 |
| BADL | | Badlands NP | SD | 43.81 | -102.36 | -8 | 20000101 |
| BALD | | Mount Baldy Wilderness | AZ | 33.95 | -109.54 | -8 | 20000101 |

| _monitor_id | monitor_lat | monitor_long | monitor_gridcell |
|---|---|---|---|
| ACAD1 | 44.3771 | -68.2610 | 82139 |
| AGTI1 | 33.4636 | -116.9706 | 44025 |
| SNPA1 | 47.4220 | -121.4259 | 88026 |
| SULA1 | 45.8598 | -114.0001 | 80040 |
| KAIS1 | 37.2207 | -119.1546 | -8 |
| CANY1 | 38.4587 | -109.8210 | 56046 |
| BADL1 | 43.7435 | -101.9412 | 70066 |
| BALD1 | 34.0584 | -109.4406 | -8 |

| Variable | Description |
|---|---|
| _id | Class I area site ID |
| _type | Leave blank. |
| _class_i_name | Class 1 area name |
| class_i_state | State of Class 1 area |
| class_i_lat | Latitude in decimal degrees of Class 1 area centroid |
| class_i_long | Longitude in decimal degrees of Class 1 area centroid |
| class_i_gridcell | Identifier of grid cell closest to the Class 1 area centroid |
| date | Meteorological modeling year |
| _monitor_id | IMPROVE site code (either at Class I area or a representative site) |
| monitor_lat | IMPROVE Monitor latitude |
| monitor_long | IMPROVE Monitor longitude |
| monitor_gridcell | Identifier of grid cell closest to the monitor |

#### 9.1.3.4 Used Model Grid Cells - Base/Future Data.csv

An example of this output file is as follows (with variable definitions in the table below):

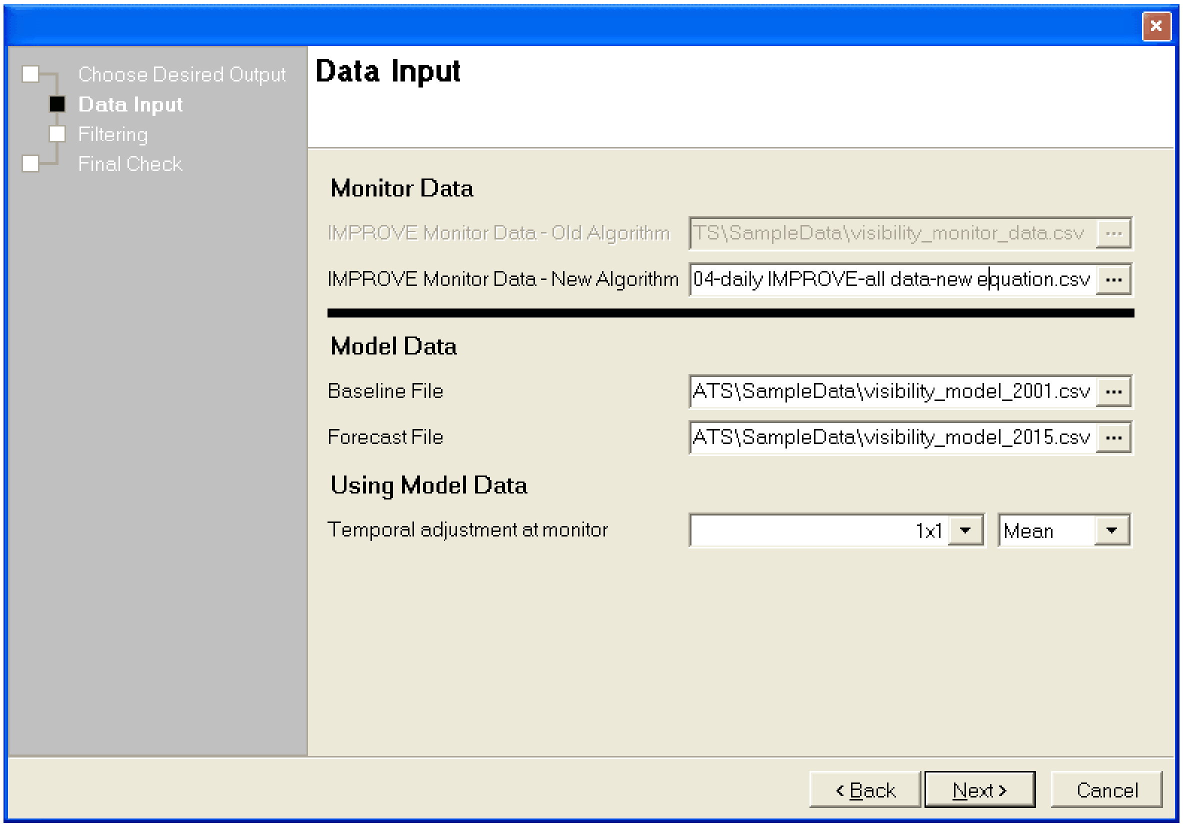
**Tutorial Visibility - Used Model Grid Cells - Base Data.csv**

| Day _id | _type | gridcell_lat | gridcell_long | date | cm | crustal | so4 | ec | no3 | oc | _visibility_rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17123 | | 25.2532 | -80.6316 | 20010104 | 0.34 | 1.63 | 2.21 | 0.63 | 0.18 | 3.69 | worst |
| 17123 | | 25.2532 | -80.6316 | 20010113 | 0.15 | 0.53 | 1.32 | 0.36 | 0.01 | 2.01 | worst |
| 17123 | | 25.2532 | -80.6316 | 20010122 | 0.43 | 1.54 | 2.63 | 0.58 | 0.02 | 3.28 | worst |
| 17123 | | 25.2532 | -80.6316 | 20010125 | 0.52 | 2.29 | 3.45 | 0.79 | 0.12 | 5.07 | worst |
| 17123 | | 25.2532 | -80.6316 | 20010128 | 0.12 | 0.85 | 1.88 | 0.55 | 0.11 | 2.60 | worst |
| 17123 | | 25.2532 | -80.6316 | 20010203 | 0.07 | 0.64 | 2.11 | 0.67 | 0.04 | 3.87 | worst |
| 17123 | | 25.2532 | -80.6316 | 20010206 | 0.46 | 2.95 | 2.88 | 1.30 | 0.36 | 7.06 | worst |

| Variable | Description |
|---|---|
| _id | The ID is a unique name for each monitor in a particular location. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.) |
| _type | Leave blank |
| gridcell_lat | Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| gridcell_long | Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| date | Date of daily average model value with YYYYMMDD format (This is a numeric variable) |
| cm | Coarse PM (ug/m3) |
| crustal | Crustal PM |
| so4 | Sulfate PM |
| ec | Elemental Carbon |
| no3 | Nitrate PM |
| oc | Organic carbon PM |
| _visibility_rank | worst = 20% worst days used in rrf calculation; best = 20% best days used in rrf calculation |

## 9.2 Data Input

In the **Data Input** window, you need to specify the monitor data and model data that you want to use. MATS comes with monitor and model data. Alternatively, you can add your own, following the monitor and model format described below. In addition, you need to specify how MATS will evaluate the model data when calculating RRFs.




### 9.2.1 Monitor Data Input

Daily monitor data, with concentration (ug/m3) and visibility (inverse megameters) measures for each species, are available from the VIEWS website http://vista.cira.colostate.edu/views/.* As described in the Forecasting Visibility section, these monitor data are used to: (1) identify the 20 percent best and worst visibility days for a given year, and (2) calculate the 5-year baseline conditions.

Note that one IMPROVE monitor is associated with each Class I site, and the calculated visibility for the IMPROVE site is assumed to representative of the Class I site. MATS comes with a default "linkage" database that provides the cross-walk that MATS uses for IMPROVE monitors and Class I Areas.

The tables in the next sub-sections present the old equation and new equation variable names and descriptions downloaded from the VIEWS website and the variable names used in MATS. The format the data read into MATS is also included.

By default, MATS includes species concentrations (measured in ug/m3) as well as extinction estimates (measured in inverse megameters) and deciview values. MATS uses the concentration estimates. In particular, it uses the variables: AMM_SO4, AMM_NO3, OMC, EC, CRUSTAL, and CM. The variable GOOD_YEAR indicates whether a particular monitor should be used for a given year. A value of "1" means the monitor can be used, and a value of "0" means that the monitor should be dropped for the year.

The variable GROUP identifies the percentile for the overall visibility level for a particular day. A value of "90" means that the particular day is among the 20 percent worst days for the year. A value of "10" means that the particular day is among the 20 percent best days for that year. (Days with other GROUP values are not needed)

There are a number of extra variables in the ambient data input file that are not directly used by MATS (such as extinction values). The additional data can be used to QA MATS output or for additional data analysis.

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* The Visibility Information Exchange Web System (VIEWS) is an online exchange of air quality data, research, and ideas designed to understand the effects of air pollution on visibility and to support the Regional Haze Rule enacted by the U.S. Environmental Protection Agency (EPA) to reduce regional haze and improve visibility in national parks and wilderness areas. http://vista.cira.colostate.edu/views/

#### 9.2.1.1 Monitor Data Description (Old Equation)

The monitor data for the old IMPROVE algorithm includes a large number of variables, so in the sample format below we have only a portion of the variables listed. The table below has a complete listing of the variables.

### Visibility Monitor Data Format (Old Algorithm)

```
Day
_ID, _TYPE, LAT, LONG, DATE, FRH, PM25, CRUSTAL, AMM_NO3, OMC, EC, PM10, CM, AM
"ACAD1","",44.3771,-68.261,20000101,3.22,8.0645,0.2171958,1.017423,2.04764,1.11
"ACAD1","",44.3771,-68.261,20000105,3.22,1.8308,0.1202492,0.111198,0.3829,0.067
"ACAD1","",44.3771,-68.261,20000108,3.22,3.2492,0.1289628,0.240972,0.95102,0.14
"ACAD1","",44.3771,-68.261,20000112,3.22,3.3448,0.144354,0.2193,0.69384,0.1866,
"ACAD1","",44.3771,-68.261,20000115,3.22,2.8856,0.1553525,0.187308,0.72184,0.19
"ACAD1","",44.3771,-68.261,20000119,3.22,4.0888,0.1827762,0.604623,1.44088,0.30
"ACAD1","",44.3771,-68.261,20000122,3.22,3.7937,0.4609729,0.372681,0.79506,0.16
"ACAD1","",44.3771,-68.261,20000126,3.22,7.9274,0.1164544,0.807927,1.19252,0.14
```

### Visibility Monitor Data Variables and Descriptions (Old Algorithm)

| Variable | Description |
|---|---|
| _ID | IMPROVE site code |
| _TYPE | Leave blank |
| LAT | Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| LONG | Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |

| | |
|---|---|
| DATE | Date of daily average ambient data with YYYYMMDD format (This is a numeric variable) |
| FRH | Monthly climatological relative humidity adjustment factor |
| PM25 | Measured PM2.5 mass (ug/m3) |
| CRUSTAL | Crustal mass ( 2.2 × [Al] + 2.49 × [Si] + 1.63 × [Ca] + 2.42 × [Fe] + 1.94 × [Ti]) |
| AMM_NO3 | Ammonium nitrate mass (NO3*1.29) |
| OMC | Organic carbon mass (OC*1.4) |
| EC | Elemental carbon |
| PM10 | PM10 mass |
| CM | Coarse mass (PM10 minus PM2.5) |
| AMM_SO4 | Ammonium sulfate (S*4.125) |
| E_AMM_SO4 | Ammonimum sulfate extinction (Mm-1) |
| E_AMM_NO3 | Ammonimum nitrate extinction |
| E_OMC | Organic mass extinction |
| E_EC | Elemental carbon extinction |
| E_CRUSTAL | Crustal extinction |
| E_CM | Coarse mass (PM10 minus PM2.5) extinction |
| TBEXT | Total bext (includes 10 Mm-1 for Rayleigh scattering) |
| DV | Deciviews (calculated from Total bext) |
| GOOD_YEAR | Denotes complete data for the year (1= all quarters >75% completeness, 0= incomplete) |
| GROUP | 90= 20% worst days and 10= 20% best days for each year (if good_year= 1) |
| POSSIBLE_NDAYS | Possible samples in quarter |
| NDAYS | Actual complete samples per quarter |
| COMPLETE_QUARTER | Quarter completeness (1= complete, 0= incomplete) |
| SF | Sulfur concentration (used to calculate ammonium sulfate) |
| SO4F | Sulfate concentration (may be used as a backup in case S is missing) |

NOTE: Character variables have names that begin with an underscore (*i.e.*, "_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

#### 9.2.1.2 Monitor Data Description (New Equation)

The monitor data for the new IMPROVE algorithm includes a large number of variables, so in the sample format below we have only a portion of the variables listed. The table below has a complete listing of the variables.

### Visibility Monitor Data Format (New Algorithm)

```
Day
_ID,_TYPE,LAT,LONG,DATE,FRH,FSRH,FLRH,FSSRH,SS_RAYLEIGH,SEA_SALT,PM25,CRUSTAL,A
ACAD1,,44.3771,-68.261,20000101,3.22,3.82,2.75,3.91,12,0,8.0645,0.2171958,1.017
ACAD1,,44.3771,-68.261,20000105,3.22,3.82,2.75,3.91,12,0,1.8308,0.1202492,0.111
ACAD1,,44.3771,-68.261,20000108,3.22,3.82,2.75,3.91,12,0,3.2492,0.1289628,0.240
ACAD1,,44.3771,-68.261,20000112,3.22,3.82,2.75,3.91,12,0,3.3448,0.144354,0.2193
ACAD1,,44.3771,-68.261,20000115,3.22,3.82,2.75,3.91,12,0.55116,2.8856,0.1553525
ACAD1,,44.3771,-68.261,20000119,3.22,3.82,2.75,3.91,12,0,4.0888,0.1827762,0.604
ACAD1,,44.3771,-68.261,20000122,3.22,3.82,2.75,3.91,12,0.192906,3.7937,0.460972
ACAD1,,44.3771,-68.261,20000126,3.22,3.82,2.75,3.91,12,2.29752,7.9274,0.1164544
```

### Visibility Monitor Data Variables and Descriptions (New Algorithm)

| Variable | Description |
|---|---|
| _ID | IMPROVE site code |
| _TYPE | Leave blank |
| LAT | Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| LONG | Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| DATE | Date of daily average ambient data with YYYYMMDD format (This is a numeric variable) |
| FRH | Monthly climatological relative humidity adjustment factor |
| FSRH | Monthly climatological relative humidity adjustment factor - small sulfate and nitrate particles |
| FLRH | Monthly climatological relative humidity adjustment factor - large sulfate and nitrate particles |
| FSSRH | Monthly climatological relative humidity adjustment factor - sea salt |
| SS_RAYLEIGH | Site-specific Rayleigh scattering (Mm-1) |
| PM25 | Measured PM2.5 mass (ug/m3) |
| SEA_SALT | Sea salt mass |
| CRUSTAL | Crustal mass ( 2.2 × [Al] + 2.49 × [Si] + 1.63 × [Ca] + 2.42 × [Fe] + 1.94 × [Ti]) |
| AMM_NO3 | Ammonium nitrate mass (NO3*1.29) |
| OMC | Organic carbon mass (OC*1.8) |
| EC | Elemental carbon |
| PM10 | PM10 mass |
| CM | Coarse mass (PM10 minus PM2.5) |
| AMM_SO4 | Ammonium sulfate (S*4.125) |
| LARGE_OMC | Large organic mass |
| SMALL_OMC | Small organic mass |
| LARGE_AMM_SO4 | Large ammonium sulfate |
| SMALL_AMM_SO4 | Small ammonium sulfate |
| LARGE_AMM_NO3 | Large ammonium nitrate |
| SMALL_AMM_NO3 | Small ammonium nitrate |
| E_AMM_SO4 | Ammonimum sulfate extinction (Mm-1) |
| E_AMM_NO3 | Ammonimum nitrate extinction |
| E_OMC | Organic mass extinction |
| E_EC | Elemental carbon extinction |
| E_CRUSTAL | Crustal extinction |
| E_CM | Coarse mass (PM10 minus PM2.5) extinction |
| E_SEA_SALT | Sea salt extinction |
| TBEXT | Total bext (includes site specific Rayleigh scattering) |

| | |
|---|---|
| DV | Deciviews (calculated from Total bext) |
| GOOD_YEAR | Denotes complete data for the year (1= all quarters >75% completeness, 0= incomplete) |
| GROUP | 90= 20% worst days and 10= 20% best days for each year (if good_year= 1) |
| POSSIBLE_NDAYS | Possible samples in quarter |
| NDAYS | Actual complete samples per quarter |
| COMPLETE_QUARTER | Quarter completeness (1= complete, 0= incomplete) |
| SF | Sulfur concentration (used to calculate ammonium sulfate) |
| SO4F | Sulfate concentration (may be used as a backup in case S is missing) |

NOTE: Character variables have names that begin with an underscore (*i.e.*, "_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

#### 9.2.1.3 Linkage between Monitors & Class I Areas

MATS comes with a default database that provides the linkage between IMPROVE monitors and Class I Areas. The file is called "156-Class I-coordinates-all site names.csv". The format of the file and the variable descriptions are as follows:

**Format for File Linking IMPROVE Monitors and Class I Areas**

```
_MONITOR_ID,MonLAT,MonLONG,_CLASS_I_NAME,_ID,_STATE_ID,LAT,LONG
ACAD1,44.3771,-68.2610,"Acadia NP",ACAD,ME,44.35,-68.24
AGTI1,33.4636,-116.9706,"Agua Tibia Wilderness",AGTI,CA,33.42,-116.99
BADL1,43.7435,-101.9412,"Badlands NP",BADL,SD,43.81,-102.36
BALD1,34.0584,-109.4406,"Mount Baldy Wilderness",BALD,AZ,33.95,-109.54
BAND1,35.7797,-106.2664,"Bandelier NM",BAND,NM,35.79,-106.34
BIBE1,29.3027,-103.1780,"Big Bend NP",BIBE,TX,29.33,-103.31
BLIS1,38.9761,-120.1025,"Desolation Wilderness",DESO,CA,38.90,-120.17
BLIS1,38.9761,-120.1025,"Mokelumne Wilderness",MOKE,CA,38.57,-120.06
BOAP1,33.8695,-106.8520,"Bosque del Apache",BOAP,NM,33.79,-106.85
```

**Variables and Descriptions for File Linking IMPROVE Monitors and Class I Areas**

| Var Name | Description (variable type) |
|---|---|
| _MONITOR_ID | IMPROVE monitor identification code (text) |
| MonLAT | IMPROVE monitor latitude (numeric) |
| MonLONG | IMPROVE monitor longitude (numeric) |
| _CLASS_I_NAME | Name of Class I Area (text) |

| | |
|---|---|
| _ID | Class I Area identification code (text) |
| _STATE_ID | State in which Class I Area is located (text) |
| LAT | Class I Area centroid latitude (numeric) |
| LONG | Class I Area centroid longitude (numeric) |

NOTE: Character variables have names that begin with an underscore (*i.e.*, "_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

### 9.2.2 Model Data Input

The model data for the 20 percent best and worst visibility days are used to calculate relative response factors (RRFs), which provide an estimate of the relative change in visibility from the baseline conditions to a future year. Recall from forecast steps that the monitor data are used to identify the best and worst days. Not the model data. MATS will match the best and worst measured days to the correct modeled days, by date. The model data input to MATS is in terms of PM species concentrations (measured in ug/m$^3$).

The following exhibits provide an example of the model data format and a description of the variables. Note that the first line of the data file gives the frequency of the data. In this case, daily data. The second line gives the variables names. The data begins on the third line. Each data line represents a daily observation.

**Format for Daily PM Model Data**

```
Day
_ID, _TYPE, LAT, LONG, DATE, CM, CRUSTAL, SO4, EC, NO3, OC
1001,"",18.362337,-121.659843,20150101,0.0001,0.0003,0.0448,0.0037,0,0.0168
1001,"",18.362337,-121.659843,20150102,0.0058,0.0166,0.1202,0.0072,0,0.0325
1001,"",18.362337,-121.659843,20150103,0.0001,0.0001,0.0838,0.0093,0,0.0412
1001,"",18.362337,-121.659843,20150104,0,0,0.2813,0.0118,0,0.0481
1001,"",18.362337,-121.659843,20150105,0,0,0.6533,0.0354,0.0008,0.1588
1001,"",18.362337,-121.659843,20150106,0,0,0.5854,0.0249,0.0005,0.1146
1001,"",18.362337,-121.659843,20150107,0,0.0001,0.8663,0.0228,0.0003,0.1017
1001,"",18.362337,-121.659843,20150108,0.0011,0.0056,0.4761,0.0147,0,0.0658
1001,"",18.362337,-121.659843,20150109,0.0153,0.057,0.3192,0.0157,0,0.0751
1001,"",18.362337,-121.659843,20150110,0.005,0.0217,0.1882,0.0123,0,0.048
1001,"",18.362337,-121.659843,20150111,0,0,0.0995,0.007,0,0.0219
1001,"",18.362337,-121.659843,20150112,0.0018,0.0022,0.1087,0.0072,0,0.0235
1001,"",18.362337,-121.659843,20150113,0.0015,0.0022,0.1335,0.008,0,0.027
1001,"",18.362337,-121.659843,20150114,0.0002,0.0006,0.1797,0.008,0,0.0256
1001,"",18.362337,-121.659843,20150115,0.0025,0.0061,0.1131,0.0069,0,0.0267
1001,"",18.362337,-121.659843,20150116,0.0189,0.0407,0.2609,0.016,0,0.0658
1001,"",18.362337,-121.659843,20150117,0.0011,0.0021,0.2342,0.0157,0,0.0532
```

**Visibility Model Data Variable Descriptions**

| Variable | Description |
|---|---|
| _ID | The ID is a unique number for each model grid cell in the air quality model domain. It is generally based on the column and row identifiers from the air quality modeling domain. The default convention is to calculate the ID by multiplying the column identifier by one thousand (1000) and adding the row identifier. (This is a character variable.) |
| _TYPE | Leave blank |
| LAT | Latitude in decimal degrees of the center of each grid cell. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative. |
| LONG | Longitude in decimal degrees of the center of each grid cell. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative. |
| DATE | Date of daily average model value with YYYYMMDD format (This is a numeric variable) |
| CM | Coarse PM (ug/m3) |
| CRUSTAL | Crustal PM |
| SO4 | Sulfate PM |
| EC | Elemental carbon |
| NO3 | Nitrate PM |
| OC | Organic mass PM |

NOTE: Character variables have names that begin with an underscore (*i.e.*, "_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

Finally, note that the species variables used by MATS do not exactly correspond to the speciated monitor data input available from the VIEWS website. The following exhibit presents the correspondence used by MATS.

| Monitor Data<br>Variable Name (from Views) | New Variable Name (used within MATS) |
|---|---|
| Soil | CRUSTAL |
| Amm_NO3 | AMM_NO3 |
| OMC | OMC |
| LAC | EC |
| CM | CM |
| Amm_SO4 | AMM_SO4 |

Regardless of the species names used by the air quality model, the model output variables should be changed to the MATS variable names when creating MATS input files.

#### 9.2.2.1 Using Model Data for Temporal Adjustment

Relative response factors (RRFs) are calculated for each species: sulfate, nitrate, EC, OMC, Crustal, and Coarse Matter (CM), by taking the ratio of the average of the 20 percent best (or worst) days in the future to the average of the 20 percent best (or worst) days in the baseline. For example, when calculating the sulfate RRF for the 20 percent best days, MATS does the following calculation:

$$RRF_{Sulfate,j} = \frac{\frac{1}{n} \cdot \sum_{i=1}^{n} Sulfate_{future,j,i}}{\frac{1}{n} \cdot \sum_{i=1}^{n} Sulfate_{baseline,j,i}}$$

where:

j = Class I area

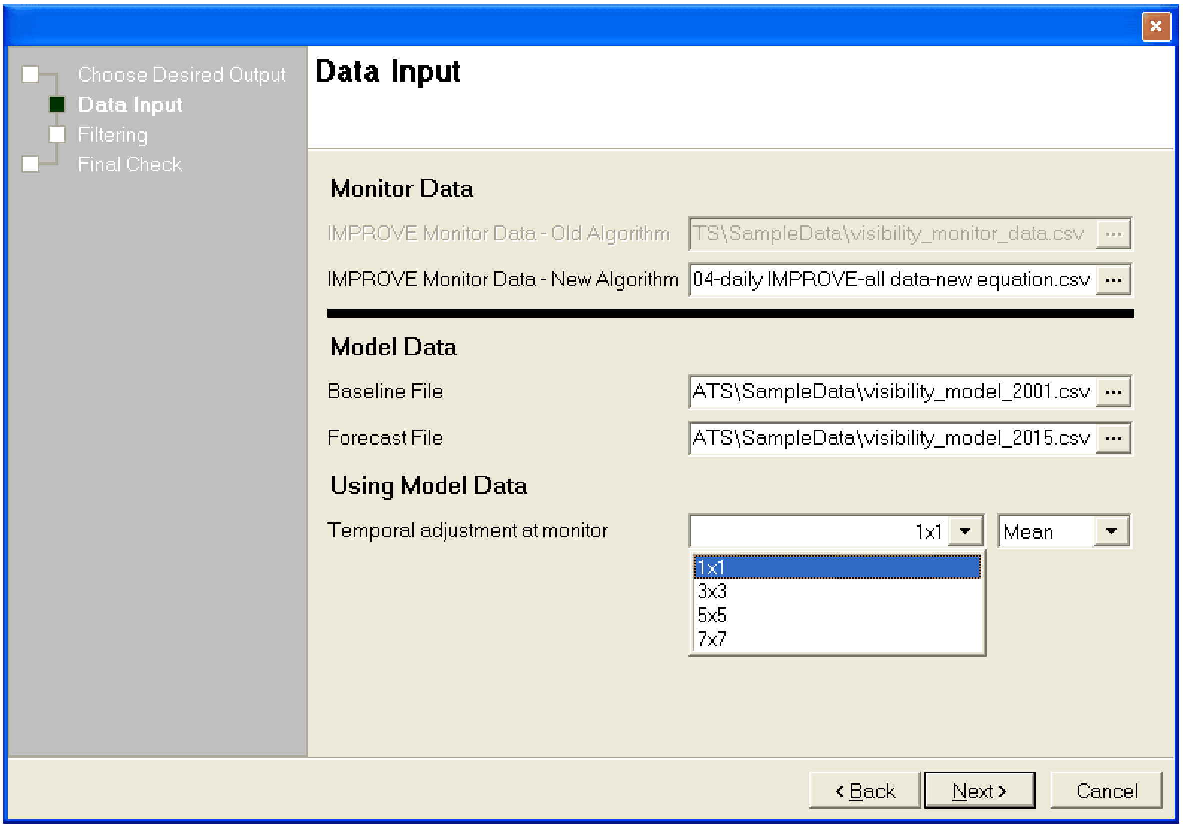
i = day identifier

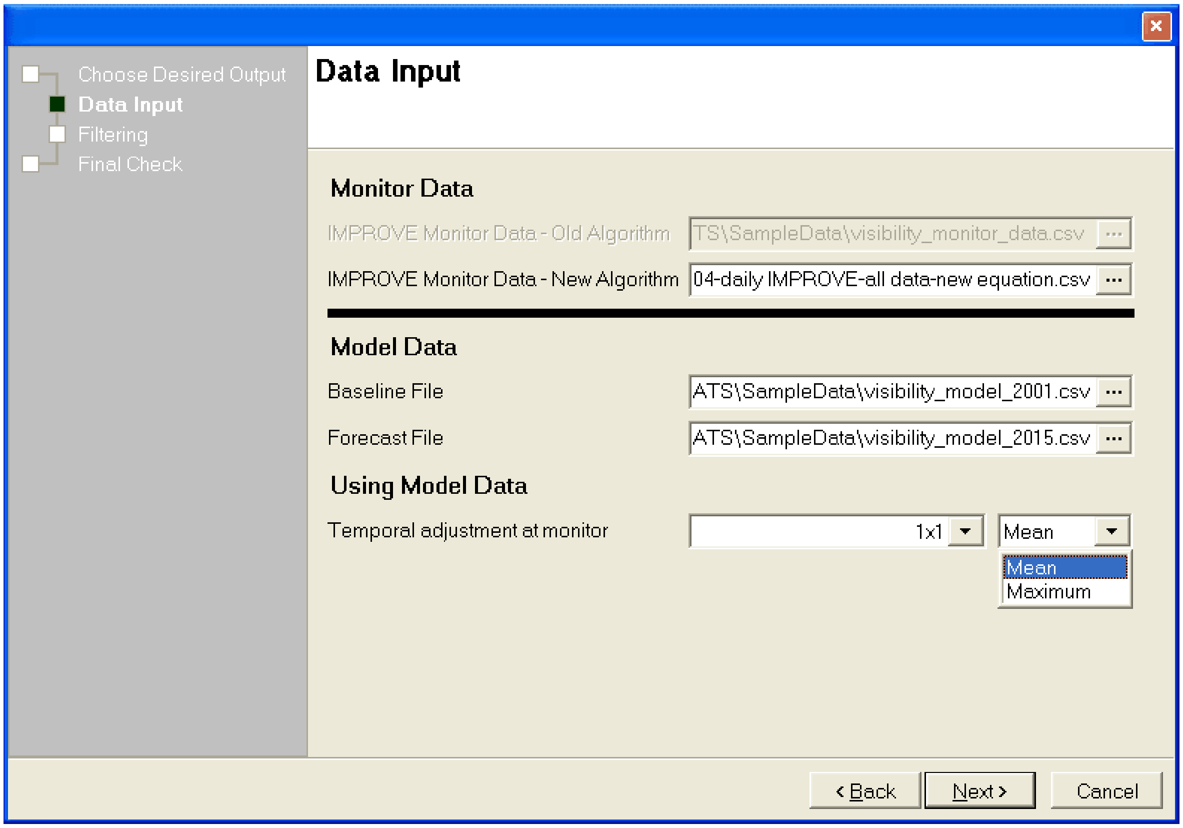
n = number of 20 percent best visibility days

Sulfate = modeled sulfate concentration (in ug/$m^3$) on best visibility days.

When identifying the model data for this calculation, MATS first determines whether you want to use model values located at the monitor or at the centroid of the Class I Area. You choose the desired location (monitor or cell centroid) in the Choose Desired Output window. In addition, you need to specify how many cells around the desired location you want to use in the calculation (*1x1* matrix, *3x3* matrix, etc), and whether you want to use the maximum or the mean of the model cells.

In the case of a *3x3* matrix with *Mean* specified, MATS identifies the speciated model values (measured in ug/$m^3$) from among the nine “nearby” grid cells for each day for each Class I Area. In the typical case, where there are 365 days of model outputs, MATS will generate 365 daily values. MATS will do this calculation separately for each species for both the baseline and future-year scenarios. The Guidance Document recommends using the *Mean* of model values when calculating the RRF. Next there is a recommended example of how MATS calculates the RRF using the *Mean* for a *3x3* matrix. (An example with the Maximum is also provided, however this is not the recommended approach for visibility calculations.)


Choose Desired Output
Data Input
Filtering
Final Check
Data Input
Monitor Data
IMPROVE Monitor Data - Old Algorithm
TS\SampleData\visibility_monitor_data.csv
IMPROVE Monitor Data - New Algorithm
04-daily IMPROVE-all data-new equation.csv
Model Data
Baseline File
ATS\SampleData\visibility_model_2001.csv
Forecast File
ATS\SampleData\visibility_model_2015.csv
Using Model Data
Temporal adjustment at monitor
1x1
Mean
1x1
3x3
5x5
7x7
< Back
Next >
Cancel




9.2.2.1.1 RRF Calculation - Example with Mean

The Guidance Document recommends using the *Mean* of the model values. In the case of a *3x3* matrix with *Mean* specified, MATS averages the speciated model values (measured in ug/$m^3$) from the nine "nearby" grid cells for each day for each Class I Area.

Assume there are eight best visibility days with the following modeled sulfate values in the baseline. MATS would average the values for each day.

| Best Days | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 | Cell 7 | Cell 8 | Cell 9 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.795 | 1.812 | 1.299 | 1.609 | 1.612 | 1.250 | 1.692 | 0.570 | 1.347 | 1.443 |
| 2 | 0.164 | 1.556 | 1.205 | 0.270 | 1.940 | 1.065 | 1.156 | 1.620 | 1.786 | 1.196 |
| 3 | 1.709 | 0.273 | 1.304 | 1.213 | 1.177 | 1.104 | 0.368 | 1.817 | 1.377 | 1.149 |
| 4 | 1.119 | 1.322 | 1.778 | 1.154 | 1.503 | 1.511 | 1.251 | 1.939 | 0.474 | 1.339 |
| 5 | 1.910 | 1.648 | 1.012 | 1.635 | 1.912 | 1.587 | 1.508 | 1.723 | 1.611 | 1.616 |
| 6 | 1.490 | 1.204 | 1.997 | 0.989 | 1.832 | 0.064 | 1.469 | 1.634 | 1.470 | 1.350 |
| 7 | 1.136 | 1.886 | 1.131 | 1.282 | 1.957 | 1.047 | 1.335 | 0.045 | 1.279 | 1.233 |
| 8 | 1.304 | 1.217 | 1.738 | 1.243 | 1.370 | 1.802 | 1.374 | 1.736 | 1.196 | 1.442 |

Assume there are eight best visibility days with the following modeled sulfate values in the forecast. Again, MATS would average the values for each day.

| Best Days | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 | Cell 7 | Cell 8 | Cell 9 | Max |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.789 | 1.715 | 1.209 | 1.560 | 1.562 | 1.224 | 1.492 | 0.489 | 1.148 | 1.354 |
| 2 | 0.137 | 1.512 | 1.162 | 0.181 | 1.939 | 1.022 | 1.113 | 1.541 | 1.593 | 1.133 |
| 3 | 1.695 | 0.208 | 1.254 | 1.198 | 1.133 | 1.102 | 0.200 | 1.244 | 1.235 | 1.030 |
| 4 | 1.090 | 1.251 | 1.627 | 1.126 | 1.470 | 1.468 | 1.120 | 1.877 | 0.325 | 1.262 |
| 5 | 1.815 | 1.552 | 0.974 | 1.549 | 1.594 | 1.546 | 1.407 | 1.707 | 1.591 | 1.526 |
| 6 | 1.327 | 1.167 | 1.880 | 0.957 | 1.756 | 0.000 | 1.318 | 1.590 | 1.392 | 1.265 |
| 7 | 0.989 | 1.805 | 1.028 | 1.212 | 1.820 | 1.010 | 1.183 | 0.042 | 1.236 | 1.147 |
| 8 | 1.127 | 1.183 | 1.673 | 1.238 | 1.291 | 1.753 | 1.220 | 1.717 | 1.004 | 1.356 |

The average across the daily means for the baseline is 1.346 ug/m3. The average of the forecast cells is 1.259. The sulfate RRF would then be calculated as: RRF = 1.259 / 1.346 = 0.935.

A similar process occurs for the other species. The end result is 12 RRFs -- two for each of the six species (*i.e.*, sulfate, nitrate, elemental carbon, organic carbon, crustal, and ammonium).

#### 9.2.2.1.2 RRF Calculation - Example with Maximum

The Modeling Guidance Document recommends using the *Mean* of the model values for visibility calculations. The example below, shows the calculations that would be involved if the *Maximum* were chosen. In the case of a *3x3* matrix with *Maximum* specified, MATS identifies identify the highest speciated model values (measured in ug/m$^3$) from among the nine "nearby" grid cells for each day for each Class I Area.

Assume there are eight best visibility days with the following modeled sulfate values in the baseline:

| Best Days | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 | Cell 7 | Cell 8 | Cell 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.795 | 1.812 | 1.299 | 1.609 | 1.612 | 1.250 | 1.692 | 0.570 | 1.347 |
| 2 | 0.164 | 1.556 | 1.205 | 0.270 | 1.940 | 1.065 | 1.156 | 1.620 | 1.786 |
| 3 | 1.709 | 0.273 | 1.304 | 1.213 | 1.177 | 1.104 | 0.368 | 1.817 | 1.377 |
| 4 | 1.119 | 1.322 | 1.778 | 1.154 | 1.503 | 1.511 | 1.251 | 1.939 | 0.474 |
| 5 | 1.910 | 1.648 | 1.012 | 1.635 | 1.912 | 1.587 | 1.508 | 1.723 | 1.611 |
| 6 | 1.490 | 1.204 | 1.997 | 0.989 | 1.832 | 0.064 | 1.469 | 1.634 | 1.470 |
| 7 | 1.136 | 1.886 | 1.131 | 1.282 | 1.957 | 1.047 | 1.335 | 0.045 | 1.279 |
| 8 | 1.304 | 1.217 | 1.738 | 1.243 | 1.370 | 1.802 | 1.374 | 1.736 | 1.196 |

MATS would choose the cells highlighted in orange:

| Best Days | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 | Cell 7 | Cell 8 | Cell 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.795 | 1.812 | 1.299 | 1.609 | 1.612 | 1.250 | 1.692 | 0.570 | 1.347 |
| 2 | 0.164 | 1.556 | 1.205 | 0.270 | 1.940 | 1.065 | 1.156 | 1.620 | 1.786 |
| 3 | 1.709 | 0.273 | 1.304 | 1.213 | 1.177 | 1.104 | 0.368 | 1.817 | 1.377 |
| 4 | 1.119 | 1.322 | 1.778 | 1.154 | 1.503 | 1.511 | 1.251 | 1.939 | 0.474 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 1.910 | 1.648 | 1.012 | 1.635 | 1.912 | 1.587 | 1.508 | 1.723 | 1.611 |
| 6 | 1.490 | 1.204 | 1.997 | 0.989 | 1.832 | 0.064 | 1.469 | 1.634 | 1.470 |
| 7 | 1.136 | 1.886 | 1.131 | 1.282 | 1.957 | 1.047 | 1.335 | 0.045 | 1.279 |
| 8 | 1.304 | 1.217 | 1.738 | 1.243 | 1.370 | 1.802 | 1.374 | 1.736 | 1.196 |

Assume there are eight best visibility days with the following modeled sulfate values in the forecast:

| Best Days | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 | Cell 7 | Cell 8 | Cell 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.789 | 1.715 | 1.209 | 1.560 | 1.562 | 1.224 | 1.492 | 0.489 | 1.148 |
| 2 | 0.137 | 1.512 | 1.162 | 0.181 | 1.939 | 1.022 | 1.113 | 1.541 | 1.593 |
| 3 | 1.695 | 0.208 | 1.254 | 1.198 | 1.133 | 1.102 | 0.200 | 1.744 | 1.235 |
| 4 | 1.090 | 1.251 | 1.627 | 1.126 | 1.470 | 1.468 | 1.120 | 1.877 | 0.325 |
| 5 | 1.815 | 1.552 | 0.974 | 1.549 | 1.894 | 1.546 | 1.407 | 1.707 | 1.591 |
| 6 | 1.327 | 1.167 | 1.880 | 0.957 | 1.756 | 0.000 | 1.318 | 1.590 | 1.392 |
| 7 | 0.989 | 1.805 | 1.028 | 1.212 | 1.820 | 1.010 | 1.183 | 0.042 | 1.236 |
| 8 | 1.127 | 1.183 | 1.673 | 1.238 | 1.291 | 1.753 | 1.220 | 1.717 | 1.004 |

MATS would choose the cells highlighted in orange. Note that the cells chosen for the forecast can differ from the cells chosen for the baseline.

| Best Days | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 | Cell 7 | Cell 8 | Cell 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.789 | 1.715 | 1.209 | 1.560 | 1.562 | 1.224 | 1.492 | 0.489 | 1.148 |
| 2 | 0.137 | 1.512 | 1.162 | 0.181 | 1.939 | 1.022 | 1.113 | 1.541 | 1.593 |
| 3 | 1.695 | 0.208 | 1.254 | 1.198 | 1.133 | 1.102 | 0.200 | 1.244 | 1.235 |
| 4 | 1.090 | 1.251 | 1.627 | 1.126 | 1.470 | 1.468 | 1.120 | 1.877 | 0.325 |
| 5 | 1.815 | 1.552 | 0.974 | 1.549 | 1.594 | 1.546 | 1.407 | 1.707 | 1.591 |
| 6 | 1.327 | 1.167 | 1.880 | 0.957 | 1.756 | 0.000 | 1.318 | 1.590 | 1.392 |
| 7 | 0.989 | 1.805 | 1.028 | 1.212 | 1.820 | 1.010 | 1.183 | 0.042 | 1.236 |
| 8 | 1.127 | 1.183 | 1.673 | 1.238 | 1.291 | 1.753 | 1.220 | 1.717 | 1.004 |

The average of the best sulfate days chosen from the baseline cells is 1.897 ug/m3. The average of the forecast cells is 1.821. The sulfate RRF would then be calculated as: RRF = 1.821 / 1.897 = 0.960.

A similar (independent) process occurs for the other species. The particular cells chosen for sulfate may be quite different from the cells chosen for, say, nitrate. Continuing with the example you might have the following pattern for baseline:

| Best Days | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 | Cell 7 | Cell 8 | Cell 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.071 | 0.133 | 0.620 | 0.788 | 0.808 | 0.964 | 0.763 | 0.938 | 0.158 |
| 2 | 0.561 | 0.891 | 0.105 | 0.689 | 0.695 | 0.302 | 0.523 | 0.209 | 0.485 |
| 3 | 0.005 | 0.384 | 0.604 | 0.077 | 0.545 | 0.046 | 0.177 | 0.664 | 0.821 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.926 | 0.651 | 0.111 | 0.334 | 0.887 | 0.548 | 0.447 | 0.547 | 0.730 |
| 5 | 0.630 | 0.995 | 0.769 | 0.888 | 0.379 | 0.121 | 0.779 | 0.130 | 0.558 |
| 6 | 0.700 | 0.761 | 0.993 | 0.556 | 0.659 | 0.877 | 0.761 | 0.474 | 0.821 |
| 7 | 0.074 | 0.189 | 0.619 | 0.987 | 0.279 | 0.757 | 0.470 | 0.189 | 0.701 |
| 8 | 0.848 | 0.100 | 0.964 | 0.535 | 0.566 | 0.315 | 0.440 | 0.011 | 0.852 |

And the following pattern for the forecast:

| Best Days | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 | Cell 7 | Cell 8 | Cell 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.068 | 0.122 | 0.556 | 0.711 | 0.766 | 0.594 | 0.653 | 0.877 | 0.152 |
| 2 | 0.514 | 0.515 | 0.092 | 0.615 | 0.687 | 0.283 | 0.460 | 0.198 | 0.479 |
| 3 | 0.004 | 0.380 | 0.513 | 0.076 | 0.504 | 0.044 | 0.175 | 0.591 | 0.801 |
| 4 | 0.769 | 0.581 | 0.099 | 0.327 | 0.852 | 0.537 | 0.416 | 0.482 | 0.719 |
| 5 | 0.563 | 0.940 | 0.673 | 0.859 | 0.374 | 0.113 | 0.685 | 0.123 | 0.505 |
| 6 | 0.610 | 0.694 | 0.910 | 0.514 | 0.621 | 0.828 | 0.649 | 0.438 | 0.794 |
| 7 | 0.072 | 0.179 | 0.597 | 0.954 | 0.244 | 0.701 | 0.428 | 0.176 | 0.695 |
| 8 | 0.837 | 0.090 | 0.940 | 0.522 | 0.500 | 0.295 | 0.434 | 0.011 | 0.809 |

The end result is 12 RRFs -- two for each of the six species (*i.e.*, sulfate, nitrate, elemental carbon, organic carbon, crustal, and ammonium).

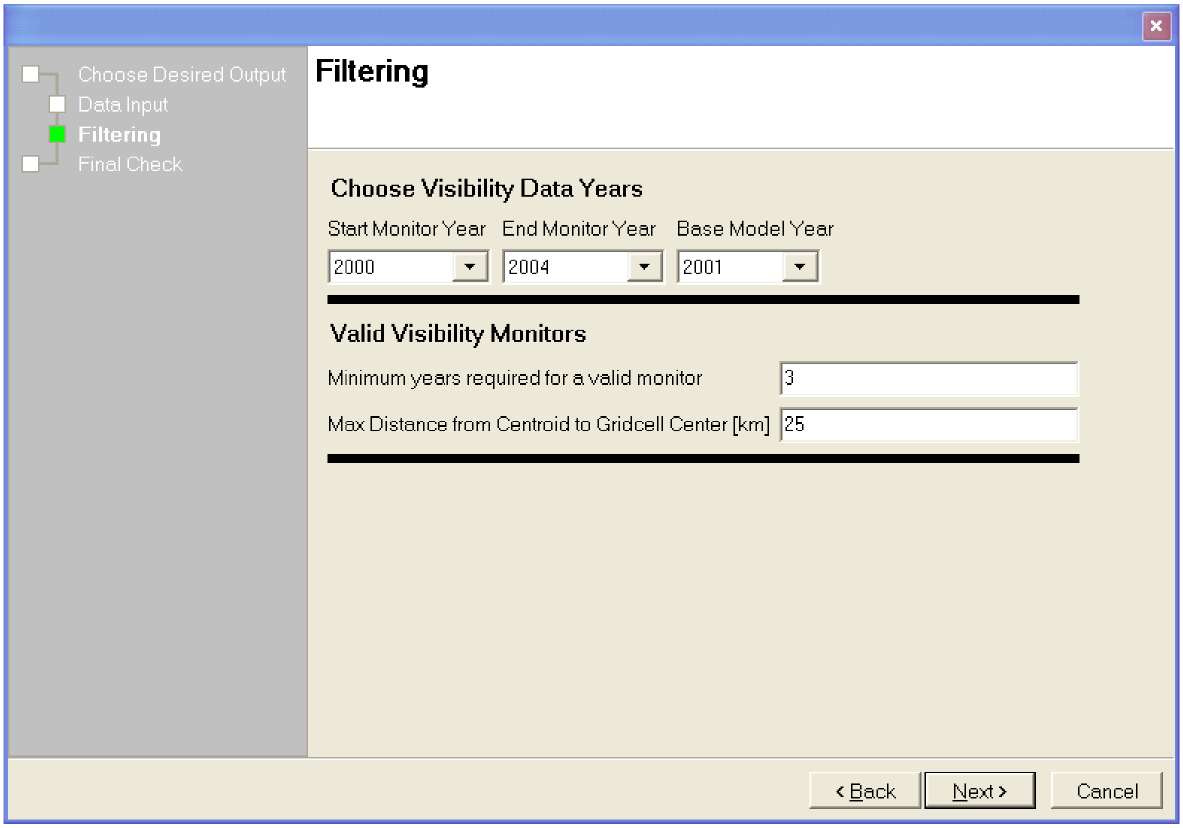
## 9.3 Filtering

MATS loads in the monitor data that you have specified in Data Input window, and then in the **Filtering** window MATS presents the available years of monitor data for your analysis. You specify a range of years with the **Start Monitor Year** and **End Monitor Year** drop-down menus.

Using the **Base Model Year** drop-down menu, you can also specify the year that you want to use to determine the "best" and "worst" monitor days. The **Base Model Year** needs to fall within the range specified by the **Start Monitor Year** and **End Monitor Year**. Once you have specified the **Base Model Year**, MATS will then identify and save for each monitor the particular dates during this year that registered the best and worst visibility days. These dates are then used to identify the model values used in the calculation of RRFs for the temporal adjustment, as seen in the Example in the Model Data Input section.

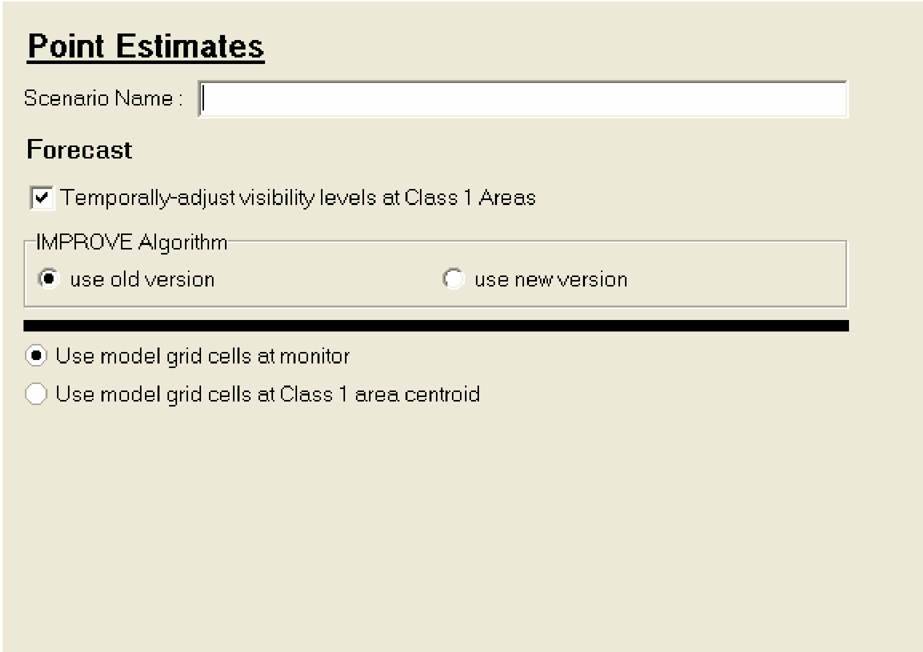
Given a particular range of years that you have chosen, you can also specify the criteria for a monitor to be included in the analysis. With the **Minimum years required for a valid monitor** box, you specify the minimum number of years of data that a monitor must have ( *e.g.*, three years).

You can also specify the **Maximum Distance from Domain**. That is, you can choose the maximum distance that a monitor (or Class I Area centroid) can be from the nearest model grid cell centroid. For example, if the **Maximum Distance from Domain** is *25*, and a monitor is more than 25 kilometers from the nearest model grid cell centroid, then a forecast is not generated for this particular monitor. (More detailed examples regarding distance and monitor validity are available here.)




### 9.3.1 Example Valid Visibility Monitors

Using the **Maximum Distance from Domain**, you can choose the maximum distance that a monitor (or Class I Area centroid) can be from the nearest model grid cell centroid. Whether you calculate the distance from a monitor or a Class I Area centroid depends on whether you have specified **Use model grid cells at monitor** or **Use model grid cells at Class I area centroid**.




**Example 1**

Assume you have chosen **Use model grid cells at monitor**. If you have set the **Maximum Distance from Domain** to *25*, and a monitor is more than 25 kilometers from the nearest model grid cell centroid, then a forecast is not generated for this particular monitor. And by extension, a forecast is not generated for the Class I Areas that are associated with this particular monitor.

Recall from the section on the [Linkage between Monitors and Class I Areas] that more than one Class I Area may be linked to a monitor. Highlighted in yellow below are some examples of monitors associated with more than Class I Area. For example, if the CHIR1 monitor is more than 25 kilometers from the nearest model grid cell centroid, then no forecasts would be generated for the three Class I Areas associated with this monitor (*i.e.*, Chiricahua NM, Chiricahua Wilderness, and Galiuro Wilderness).

| _MONITOR_ID | MonLAT | MonLONG | _CLASS_I_NAME | _ID | _STATE_ID | LAT | LONG |
|---|---|---|---|---|---|---|---|
| ACAD1 | 44.377 | -68.261 | Acadia NP | ACAD | ME | 44.35 | -68.24 |
| AGTI1 | 33.464 | -116.971 | Agua Tibia Wilderness | AGTI | CA | 33.42 | -116.99 |
| BADL1 | 43.744 | -101.941 | Badlands NP | BADL | SD | 43.81 | -102.36 |
| BALD1 | 34.058 | -109.441 | Mount Baldy Wilderness | BALD | AZ | 33.95 | -109.54 |
| BAND1 | 35.780 | -106.266 | Bandelier NM | BAND | NM | 35.79 | -106.34 |
| BIBE1 | 29.303 | -103.178 | Big Bend NP | BIBE | TX | 29.33 | -103.31 |
| BLIS1 | 38.976 | -120.103 | Desolation Wilderness | DESO | CA | 38.9 | -120.17 |
| BLIS1 | 38.976 | -120.103 | Mokelumne Wilderness | MOKE | CA | 38.57 | -120.06 |
| BOAP1 | 33.870 | -106.852 | Bosque del Apache | BOAP | NM | 33.79 | -106.85 |
| BOWA1 | 47.947 | -91.496 | Boundary Waters Canoe Area | BOWA | MN | 48.06 | -91.43 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BRCA1 | 37.618 | -112.174 | Bryce Canyon NP | BRCA | UT | 37.57 | -112.17 |
| BRET1 | 29.119 | -89.207 | Breton | BRET | LA | 29.87 | -88.82 |
| BRID1 | 42.975 | -109.758 | Bridger Wilderness | BRID | WY | 42.99 | -109.49 |
| BRID1 | 42.975 | -109.758 | Fitzpatrick Wilderness | FITZ | WY | 43.24 | -109.6 |
| BRIG1 | 39.465 | -74.449 | Brigantine | BRIG | NJ | 39.49 | -74.39 |
| CABI1 | 47.955 | -115.671 | Cabinet Mountains Wilderness | CABI | MT | 48.18 | -115.68 |
| CACR1 | 34.454 | -94.143 | Caney Creek Wilderness | CACR | AR | 34.41 | -94.08 |
| CANY1 | 38.459 | -109.821 | Arches NP | ARCH | UT | 38.73 | -109.58 |
| CANY1 | 38.459 | -109.821 | Canyonlands NP | CANY | UT | 38.23 | -109.91 |
| CAPI1 | 38.302 | -111.293 | Capitol Reef NP | CAPI | UT | 38.06 | -111.15 |
| CHAS1 | 28.748 | -82.555 | Chassahowitzka | CHAS | FL | 28.69 | -82.66 |
| CHIR1 | 32.009 | -109.389 | Chiricahua NM | CHIR | AZ | 32.01 | -109.34 |
| CHIR1 | 32.009 | -109.389 | Chiricahua Wilderness | CHIW | AZ | 31.86 | -109.28 |
| CHIR1 | 32.009 | -109.389 | Galiuro Wilderness | GALI | AZ | 32.6 | -110.39 |
| COHU1 | 34.785 | -84.627 | Cohutta Wilderness | COHU | GA | 34.93 | -84.57 |
| CRLA1 | 42.896 | -122.136 | Crater Lake NP | CRLA | OR | 42.92 | -122.13 |
| CRLA1 | 42.896 | -122.136 | Diamond Peak Wilderness | DIPE | OR | 43.53 | -122.1 |
| CRLA1 | 42.896 | -122.136 | Gearhart Mountain Wilderness | GEMO | OR | 42.51 | -120.86 |
| CRLA1 | 42.896 | -122.136 | Mountain Lakes Wilderness | MOLA | OR | 42.33 | -122.11 |
| CRMO1 | 43.461 | -113.555 | Craters of the Moon NM | CRMO | ID | 43.39 | -113.54 |

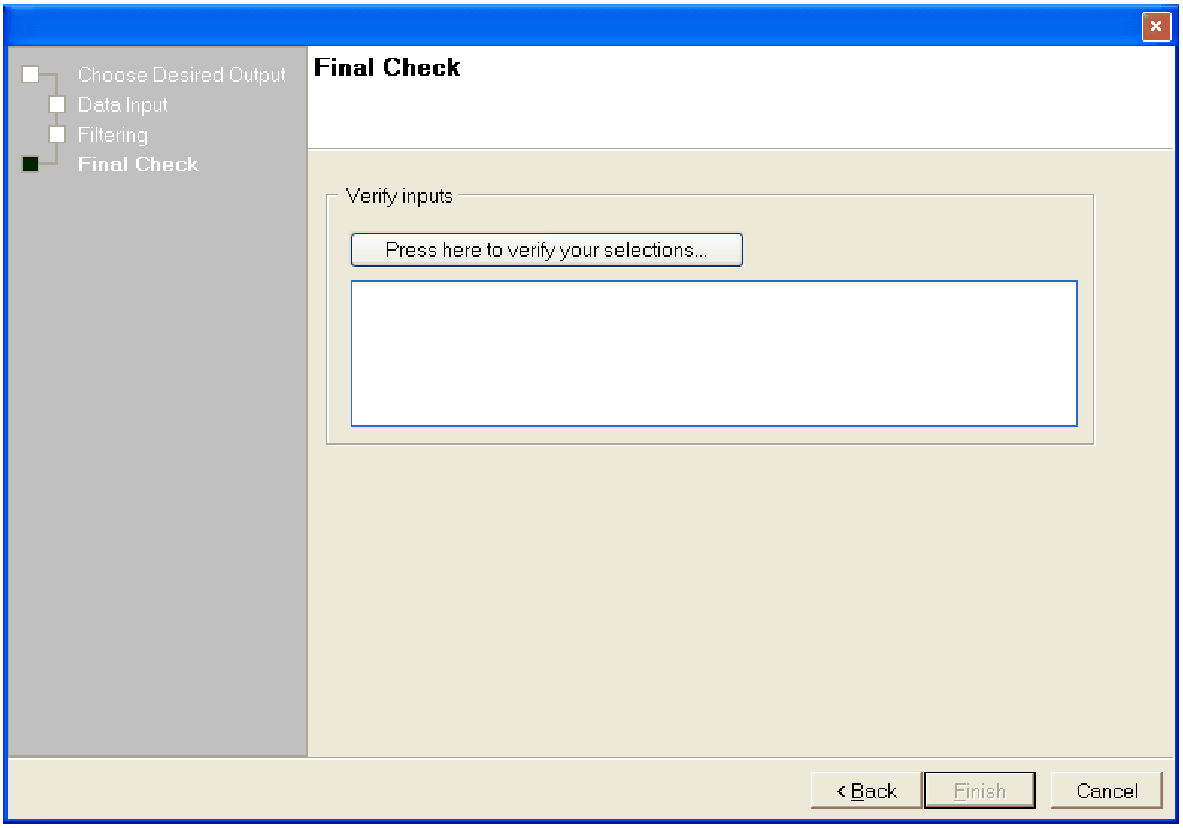
**Example 2**

Assume you have chosen **Use model grid cells at Class I area centroid**. If you have set the **Maximum Distance from Domain** to *25*, and a Class I Area is more than 25 kilometers from the nearest model grid cell centroid, then a forecast is not generated for this particular Class I Area (*e.g.*, Chiricahua, NM).

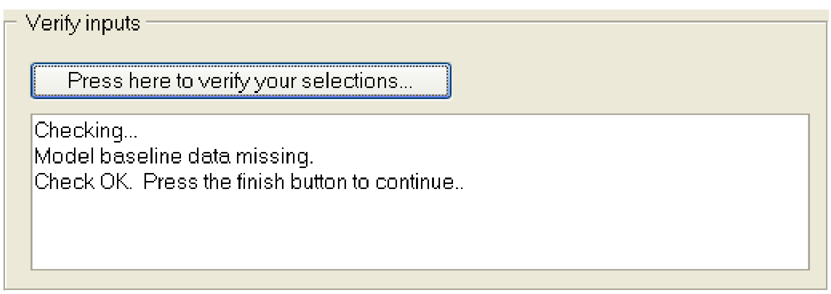
As noted above, the CHIR1 monitor is linked to two other Class I Areas. If these two other areas are within 25 kilometers of a model grid cell centroid, then the monitor values from CHIR1 would be used in the forecast for these two areas (along with the model values associated with the centroid of each area).

## 9.4 Final Check

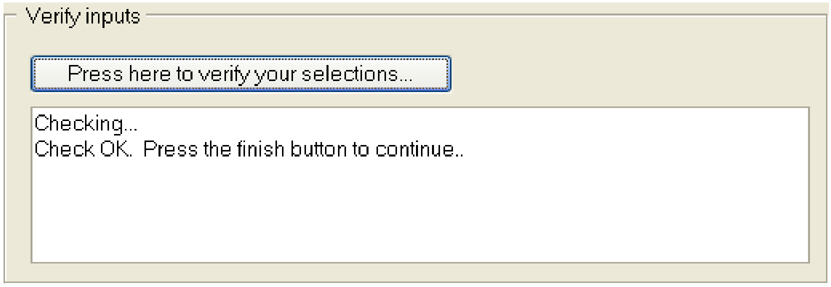
The Final Check window verifies the selections that you have made.




Click the button **Press here to verify your selections**. If there are any errors, MATS will present a message letting you know. For example, if the path to a model file is invalid -- perhaps you misspelled the file name -- you would get the following error:



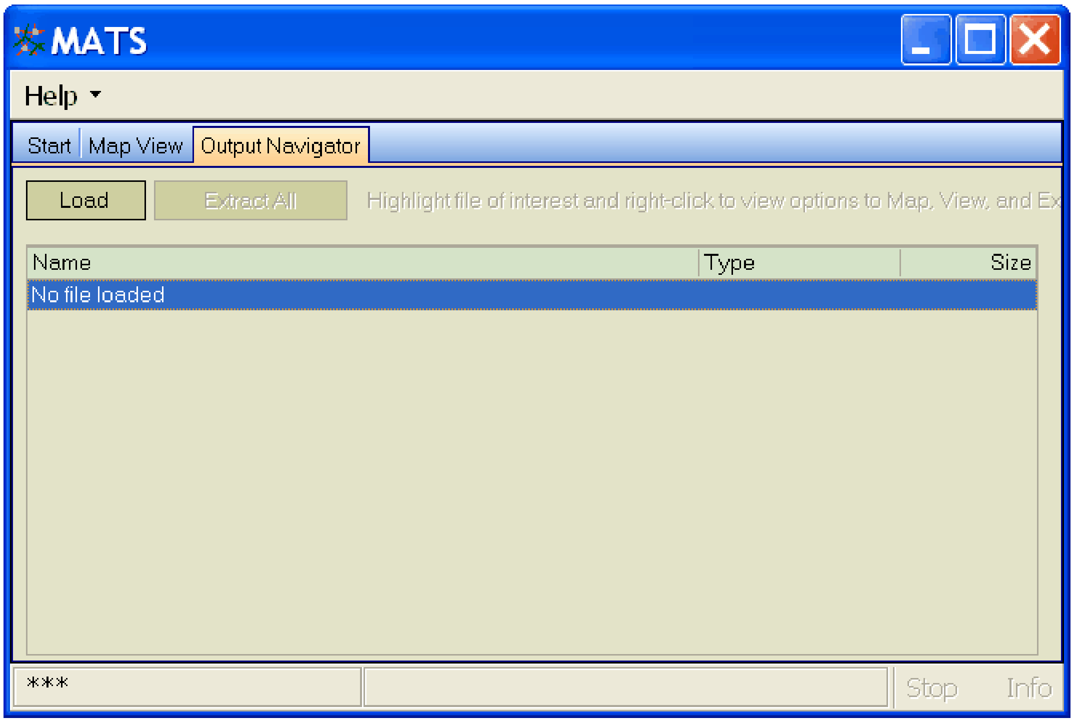

After making the necessary correction, click the button **Press here to verify your selections**. Then click the **Finish** button.


Verify inputs
Press here to verify your selections...
Checking...
Check OK.  Press the finish button to continue..

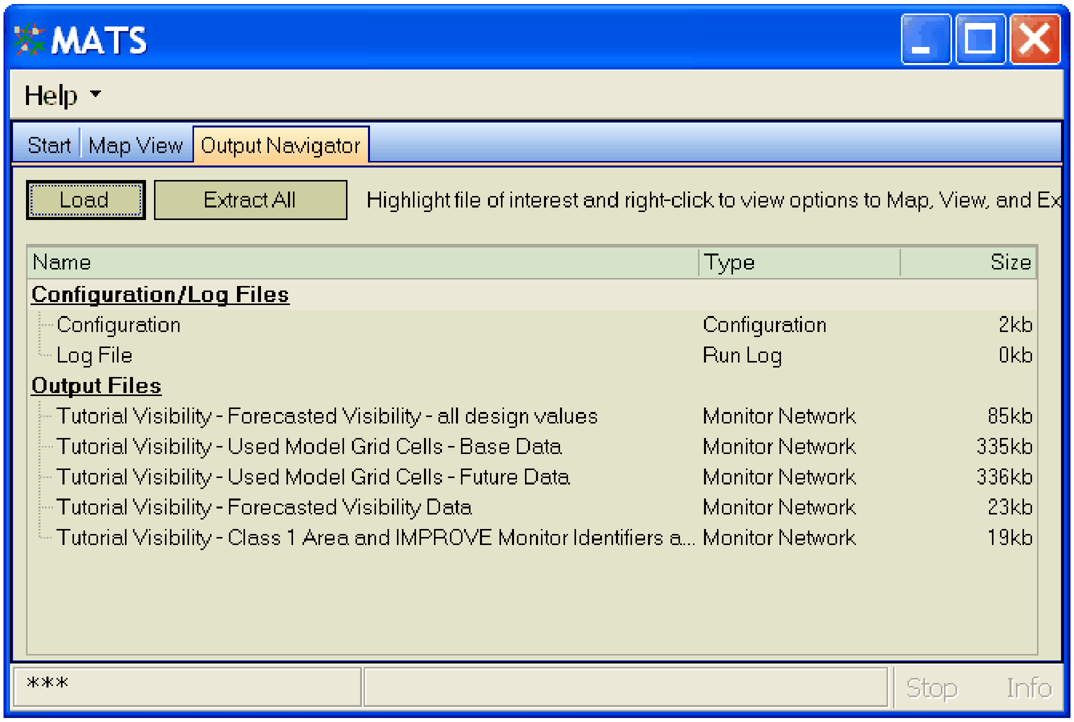
# 10 Output Navigator

The **Output Navigator** allows you to load results files (*i.e.*, *.ASR files) that you have previously created in MATS. You can view these data in maps and in tables, or export the data to text files that you can then work with in a program such as Excel.

To start, just click on the **Output Navigator** tab.

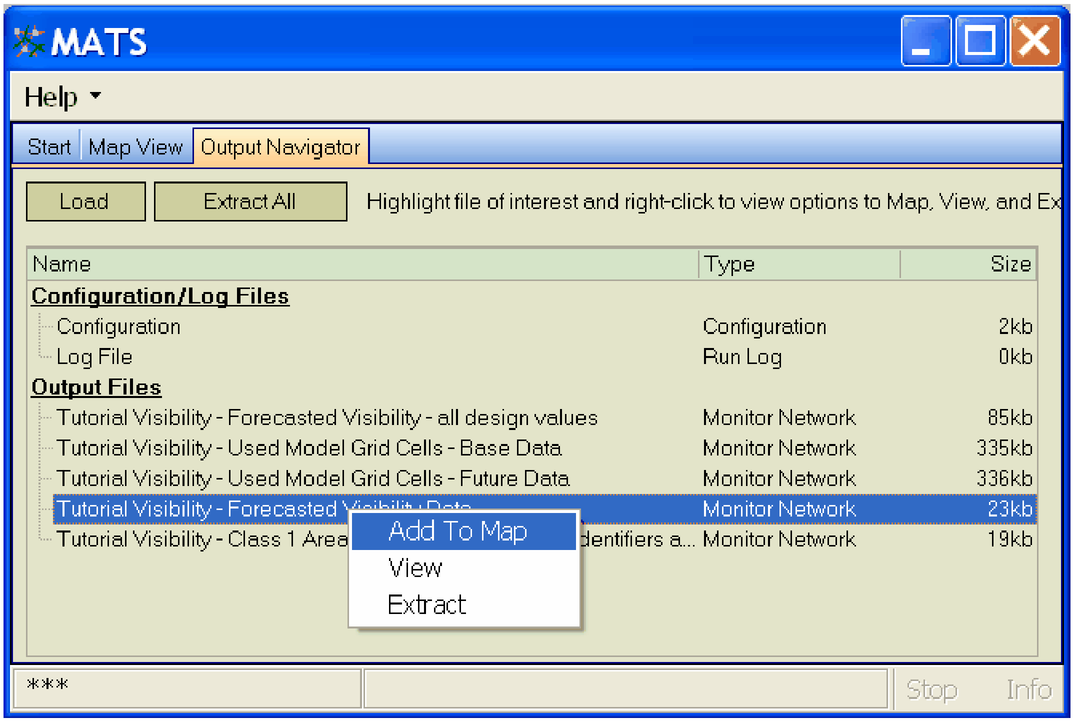



Click on the **Load** button to view your file of interest. This will bring up the **Open MATS Results file** window. Choose a results file (with the .ASR extension) This will bring you back to the Output Navigator and display the available files.

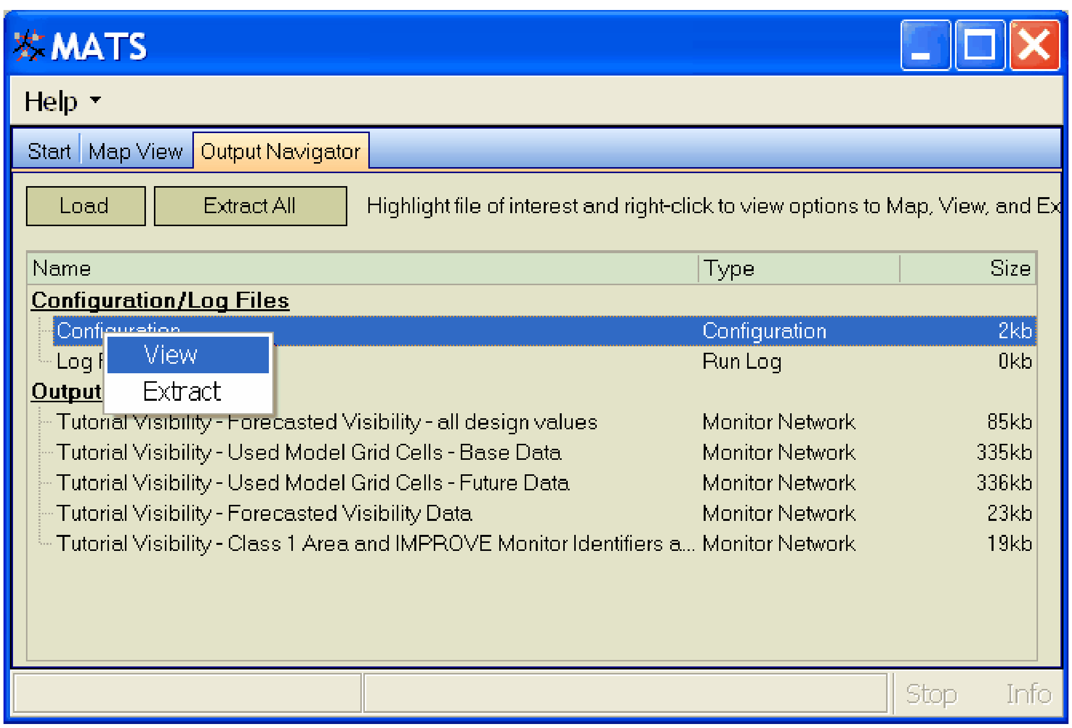



The files listed fall into two categories: **Configuration/Log Files** and **Output Files**. The Configuration File stores the assumptions used in generating your results file. The Log File stores information regarding the version of MATS used to create the results file and the date and time of its creation.

To examine a file, right-click on the file that you want to view. For **Output Files**, this will give you three choices, *Add to Map*, *View*, and *Extract*.

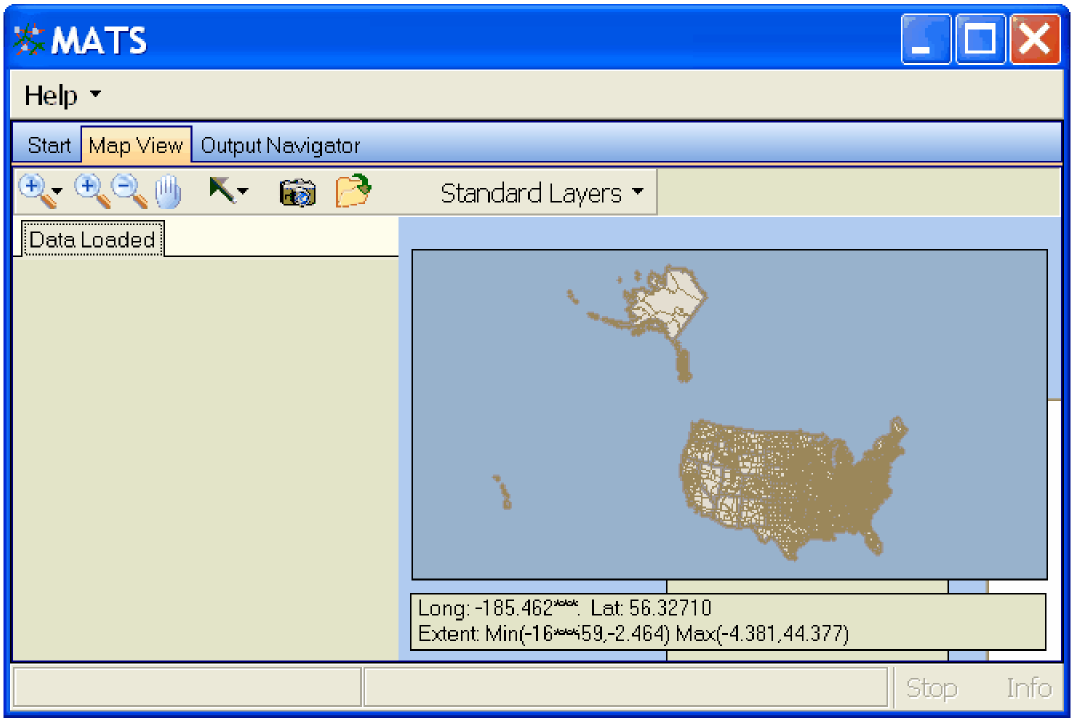



For the Configuration File and Log File you will see two options: *View* and *Extract*.

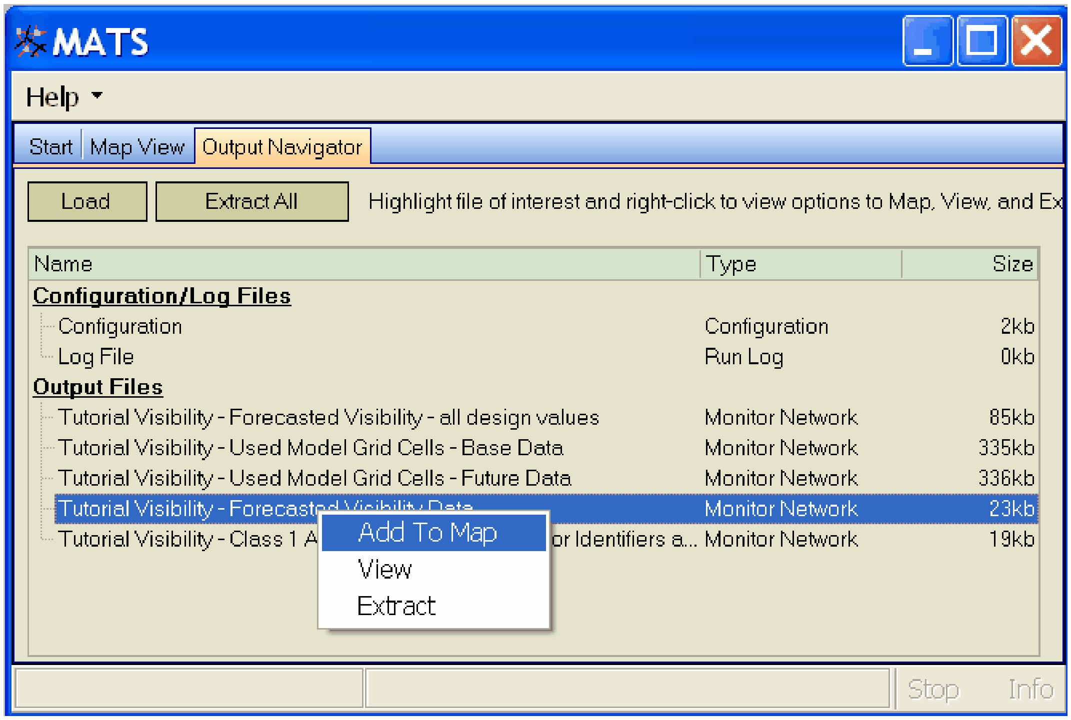


## 10.1 Add Output Files to Map

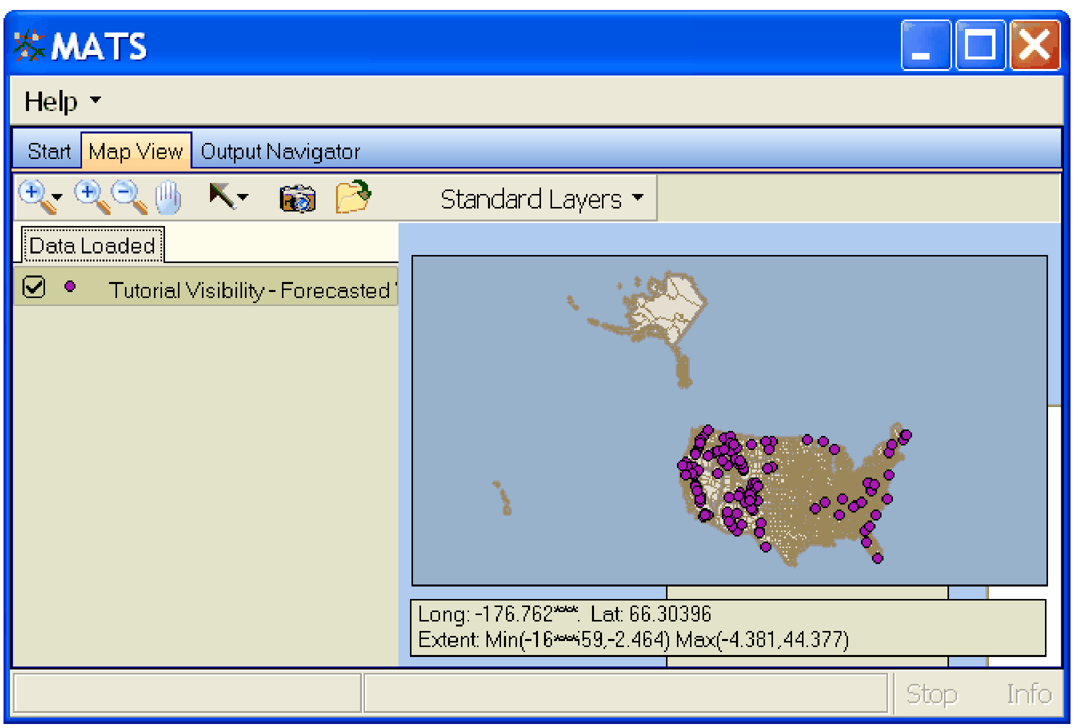
The **Map View** tab is initially empty, starting with just a blank map of the United States.




To map your results, click on the **Output Navigator** tab. Load the ASR file that you want to view and then right-click on the particular Output File that you want to map. This will give you three choices, *Add to Map*, *View*, and *Extract*.* Choose the *Add To Map* option.




This will bring you back to the **Map View** tab.



Details on how to generate a variety of maps are in the Map View chapter.

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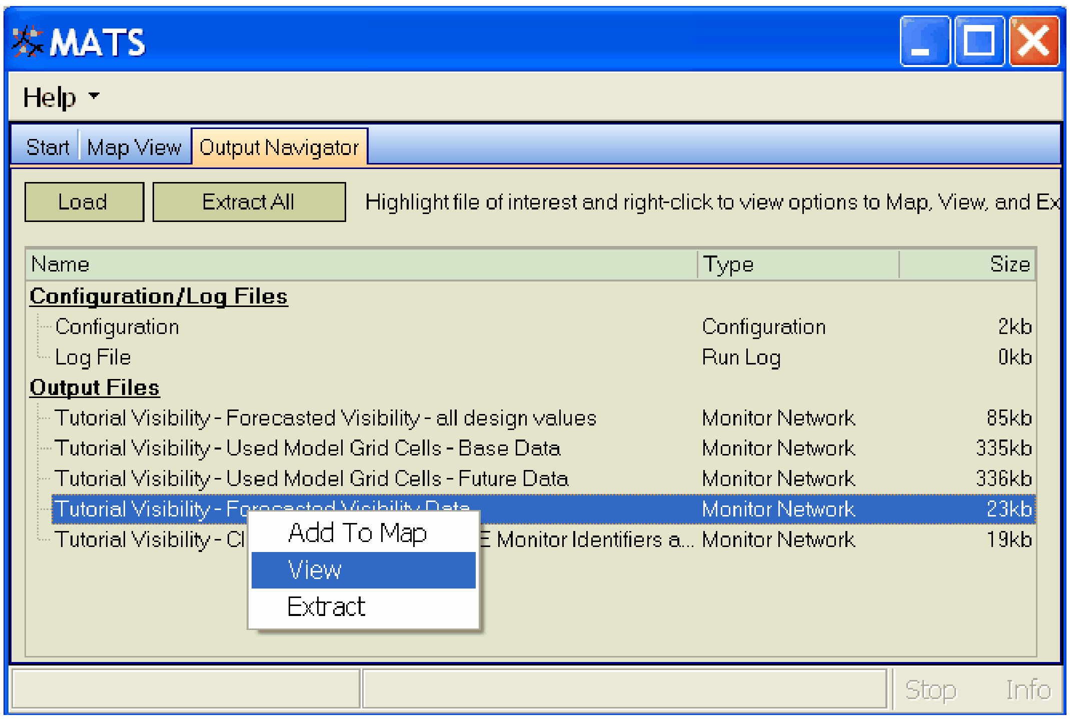
* Note that if you right-click on the Configuration File or Log File you will only see two options: *View* and *Extract*. The Add To Map option is only relevant to the **Output Files**, as the **Configuration** and **Log** files do not have a geographic component.

## 10.2 View Files

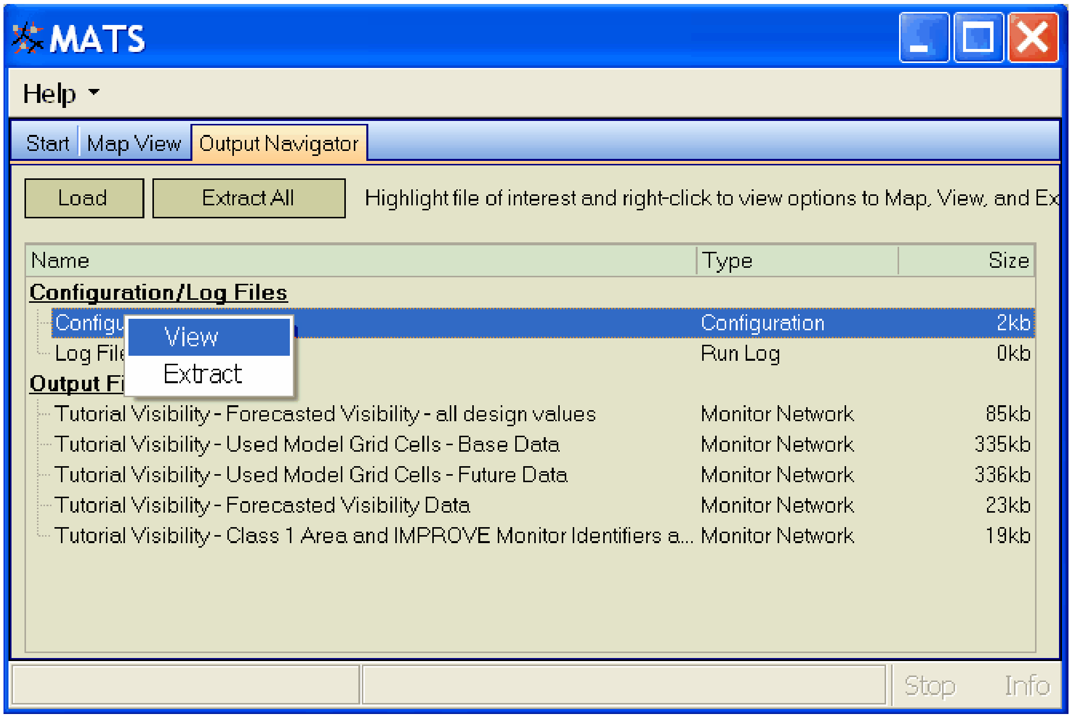
To view a file of interest, right-click on it, and then choose *View*. There are three basic types of files available: Configuration, Log, and Output files.



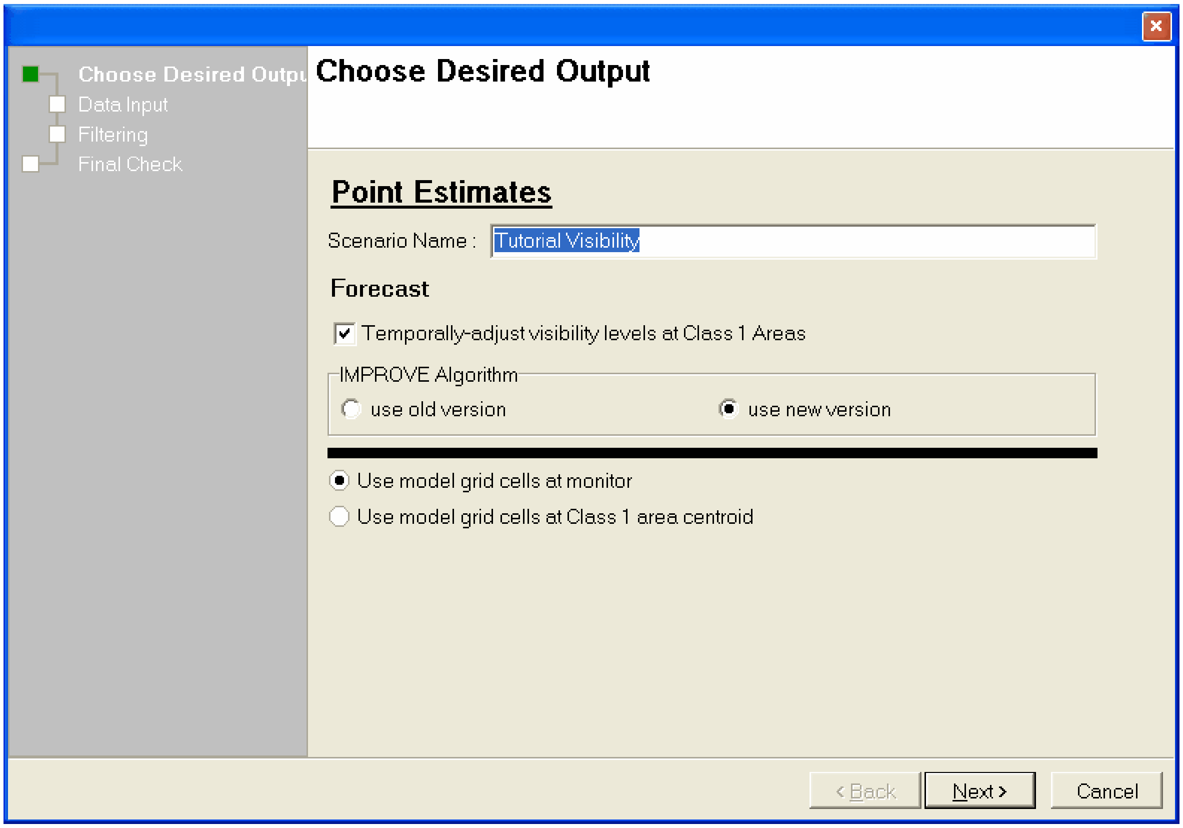

### 10.2.1 Configuration File

A Configuration File stores the choices that you have made when using MATS. A useful feature of a Configuration File is that it is reusable. You can use an existing Configuration File, make some minor changes to generate a new set of results, without having to explicitly set each of the choices you made in the previous Configuration.

To view a Configuration file from the **Output Navigator**, right-click on the file.



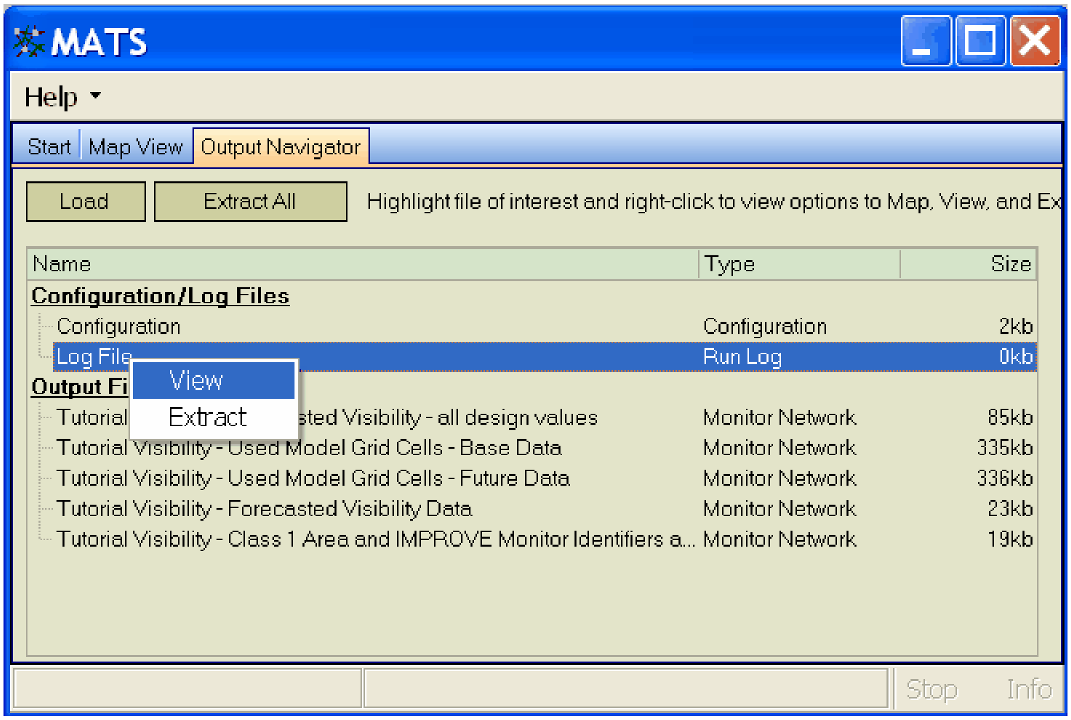

This will bring up the options that you chose when generating your results.



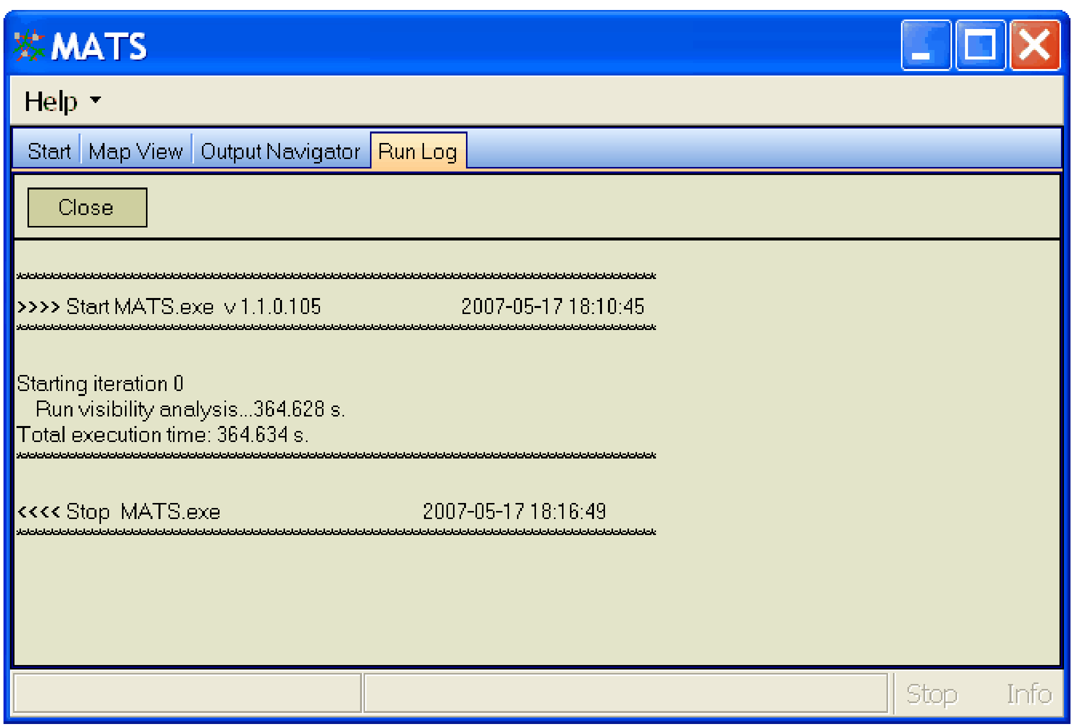

### 10.2.2 Log File

A Log File provides information on a variety of technical aspects regarding how a results file (*.ASR) was created. This includes the version of MATS, the date and time the *.ASR file was created.

To view a Log file from the **Output Navigator**, right-click on the file.




A separate **Run Log** tab will appear.

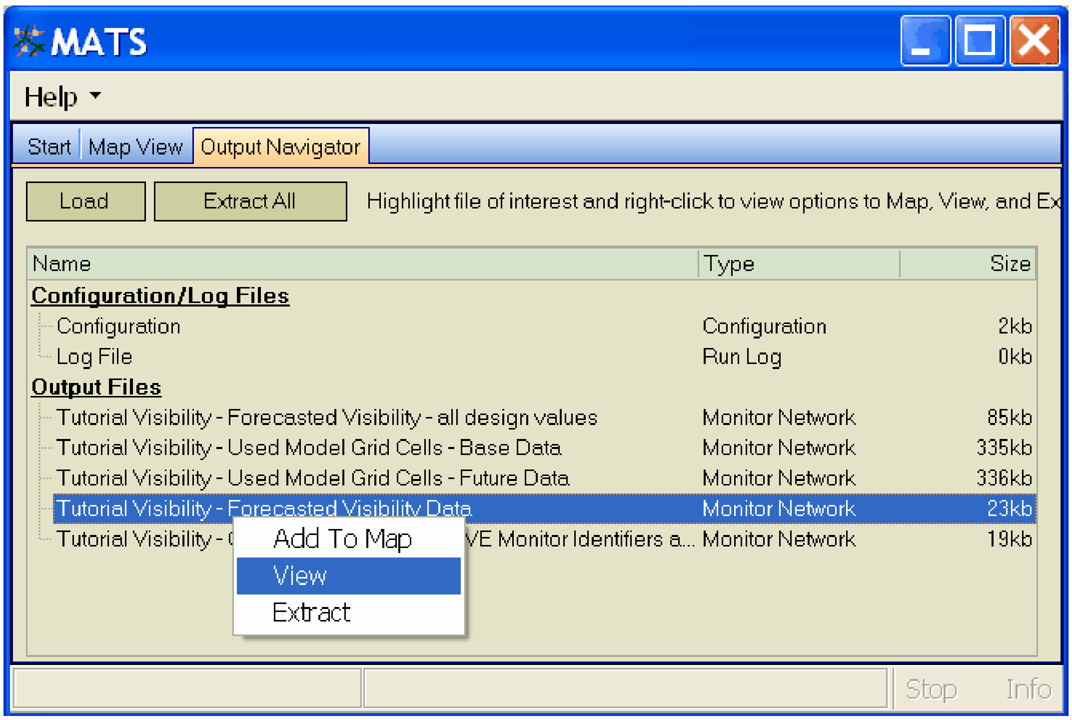


Click the **Close** button when you have finished viewing it. (The Run Log tab will disappear.)

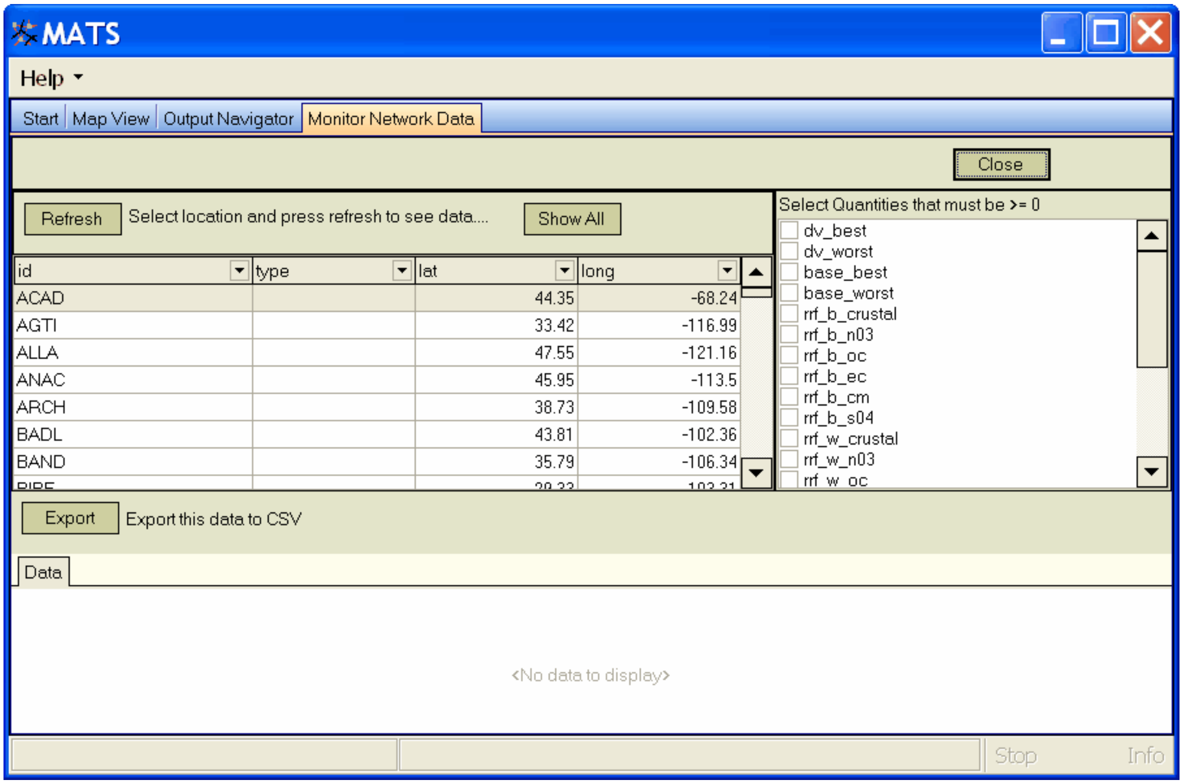
### 10.2.3 Output Files

An Output file is one of the file types within a *.ASR results file. The types of Output Files available depend on the type of analysis (PM, Ozone, or Visibility) and the output choices that you have specified in the Configuration File.

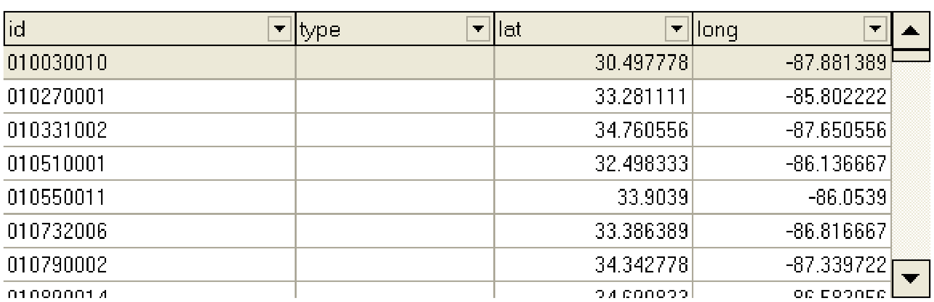
To view an Output file **Output Navigator**, right-click on a file.




This will bring up a separate tab with the data available for viewing.

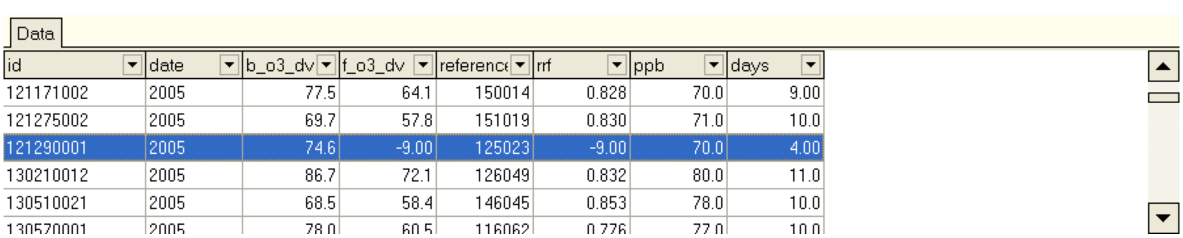



The upper left panel has the ID and latitude and longitude for each point in the dataset.



| id | type | lat | long |
|---|---|---|---|
| 010030010 | | 30.497778 | -87.881389 |
| 010270001 | | 33.281111 | -85.802222 |
| 010331002 | | 34.760556 | -87.650556 |
| 010510001 | | 32.498333 | -86.136667 |
| 010550011 | | 33.9039 | -86.0539 |
| 010732006 | | 33.386389 | -86.816667 |
| 010790002 | | 34.342778 | -87.339722 |

Clicking the **Show All** button will cause the data to appear in the lower panel.

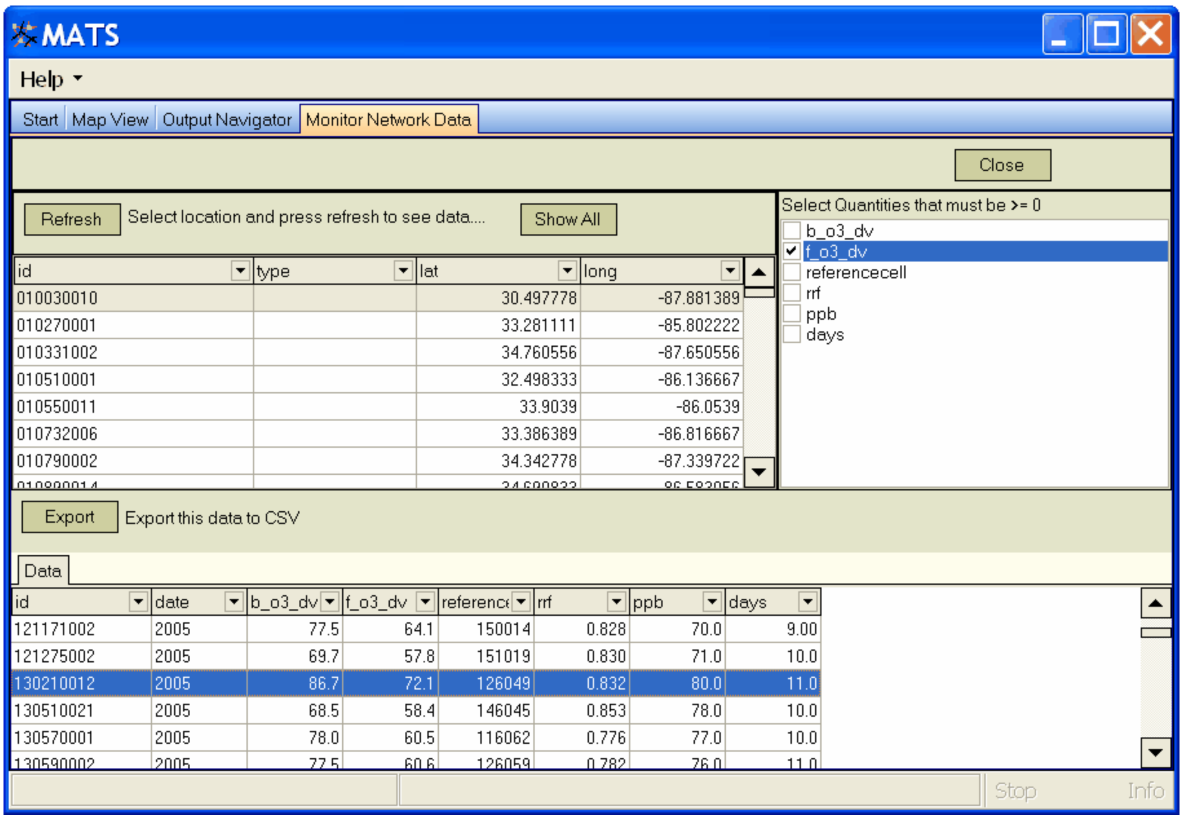


Data

| id | date | b_o3_dv | f_o3_dv | referenc | rrf | ppb | days |
|---|---|---|---|---|---|---|---|
| 121171002 | 2005 | 77.5 | 64.1 | 150014 | 0.828 | 70.0 | 9.00 |
| 121275002 | 2005 | 69.7 | 57.8 | 151019 | 0.830 | 71.0 | 10.0 |
| 121290001 | 2005 | 74.6 | -9.00 | 125023 | -9.00 | 70.0 | 4.00 |
| 130210012 | 2005 | 86.7 | 72.1 | 126049 | 0.832 | 80.0 | 11.0 |
| 130510021 | 2005 | 68.5 | 58.4 | 146045 | 0.853 | 78.0 | 10.0 |

The upper right panel allows you to select choose output with values greater than zero. After choosing one or more variables, click the **Show All** button.

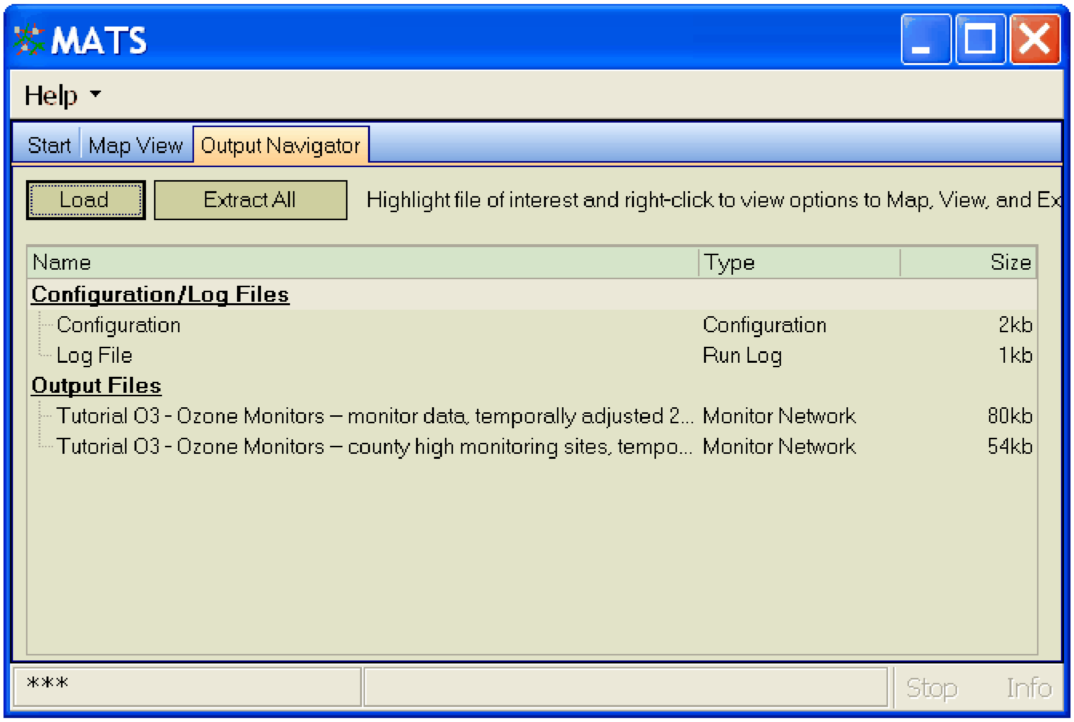
Note that missing values have a value of "-9", so this allows you to eliminate missing data. In the example below, the values for ID "121290001" are removed because the value for "f_o3_dv" is missing.



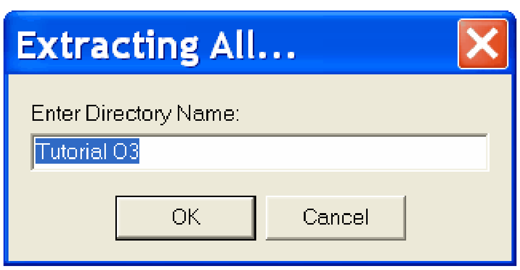

## 10.3 Extract Files

Extracting files allows you to export files from MATS and view them in another program. This is most relevant to the Output files, which you may want to view and manipulate in a database program such as Excel. MATS will generate .CSV files. These are easily viewable in a number of programs.

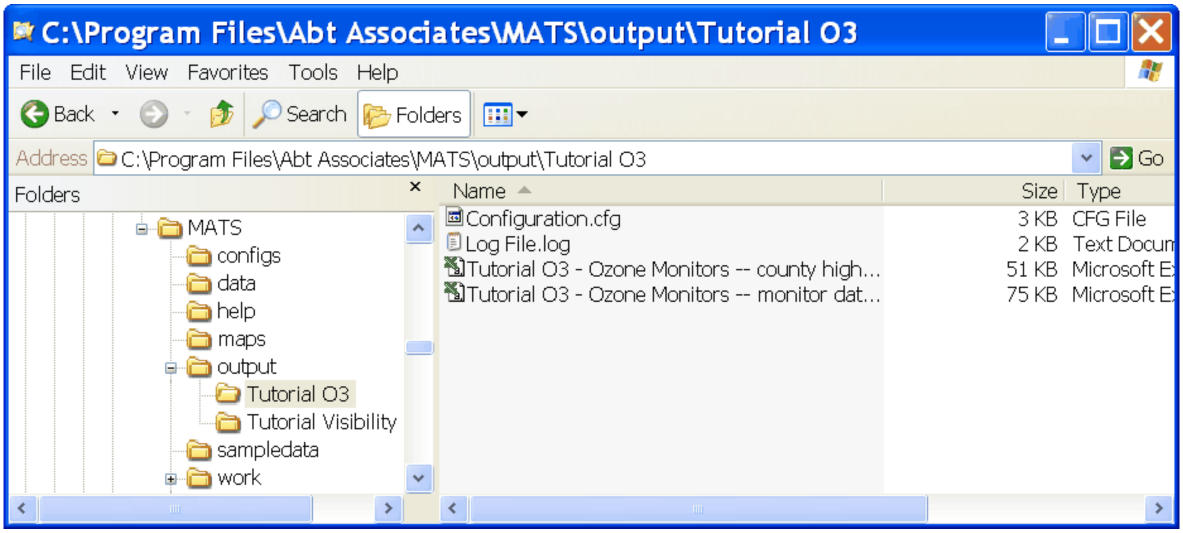
From Output Navigator load the results (.ASR) file of interest.



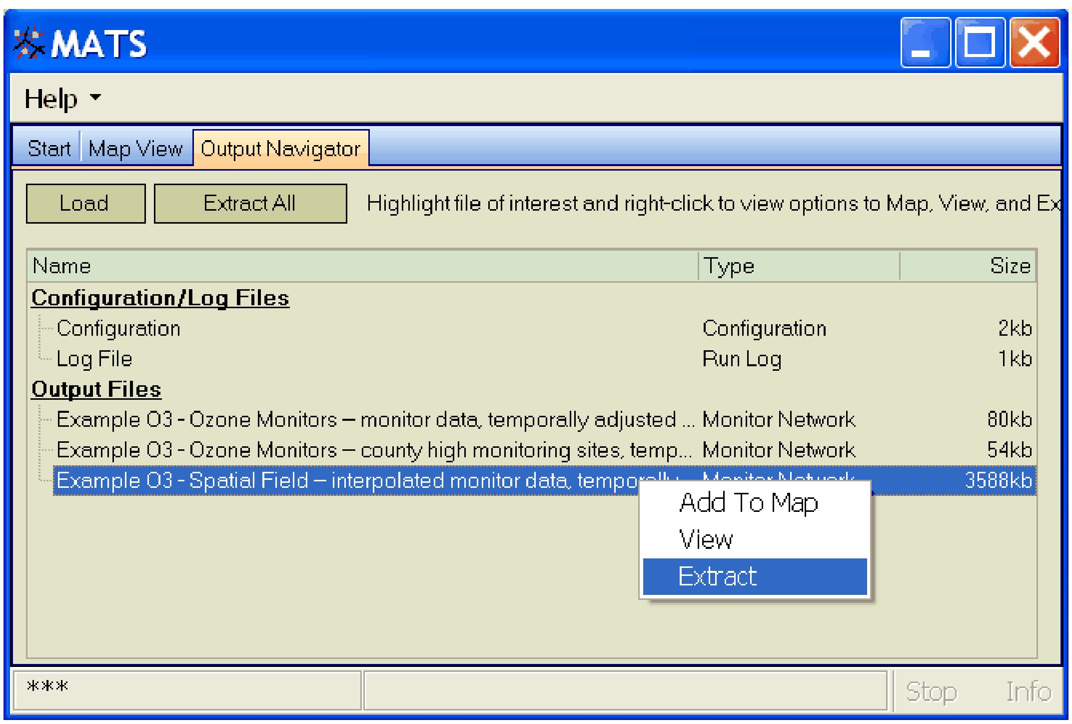

One quick method to extract all of the data in the results file is to click the **Extract All** button. An **Extracting All** screen will appear with a suggested name for the folder storing the results. MATS will use the Scenario Name as the default folder name. If desired you can rename the folder to whatever you desire.



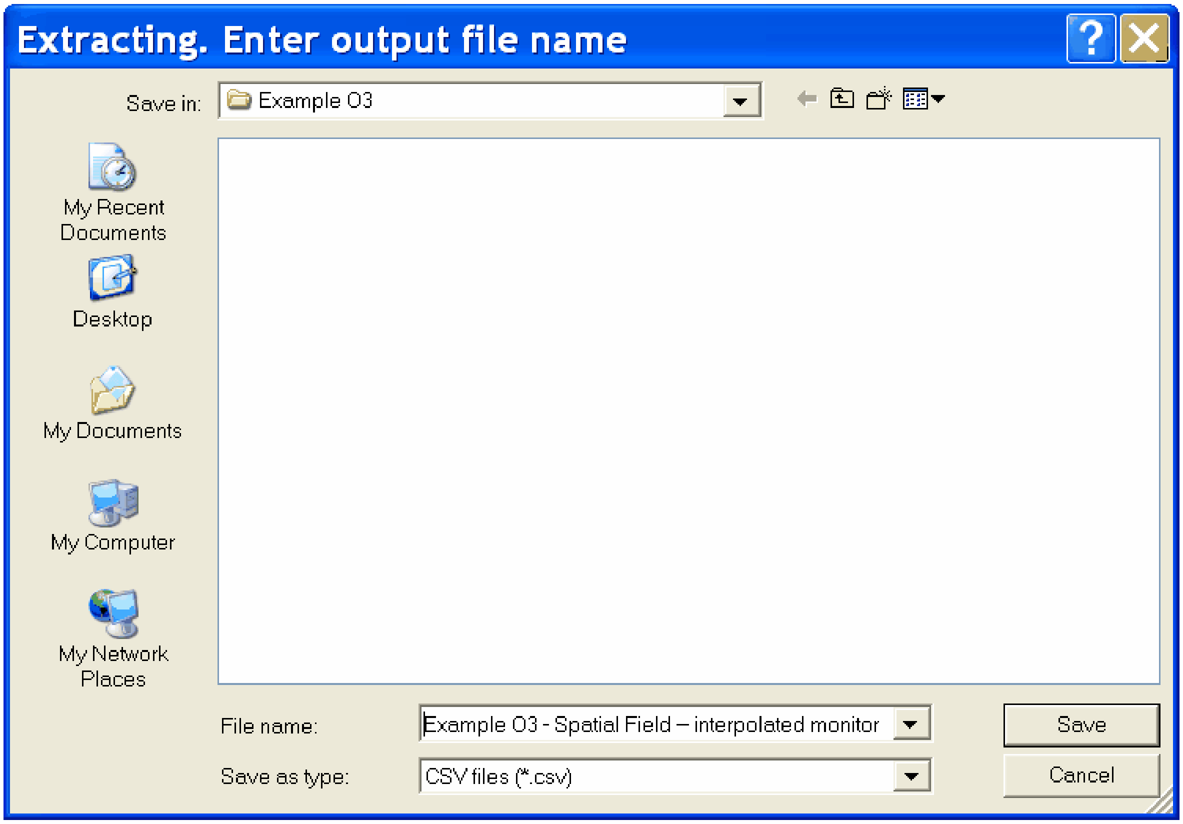

Click OK, and then MATS will export all of the files to this folder.




An alternative is to extract individual files. Right click on the file of interest, and choose the *Extract* option.

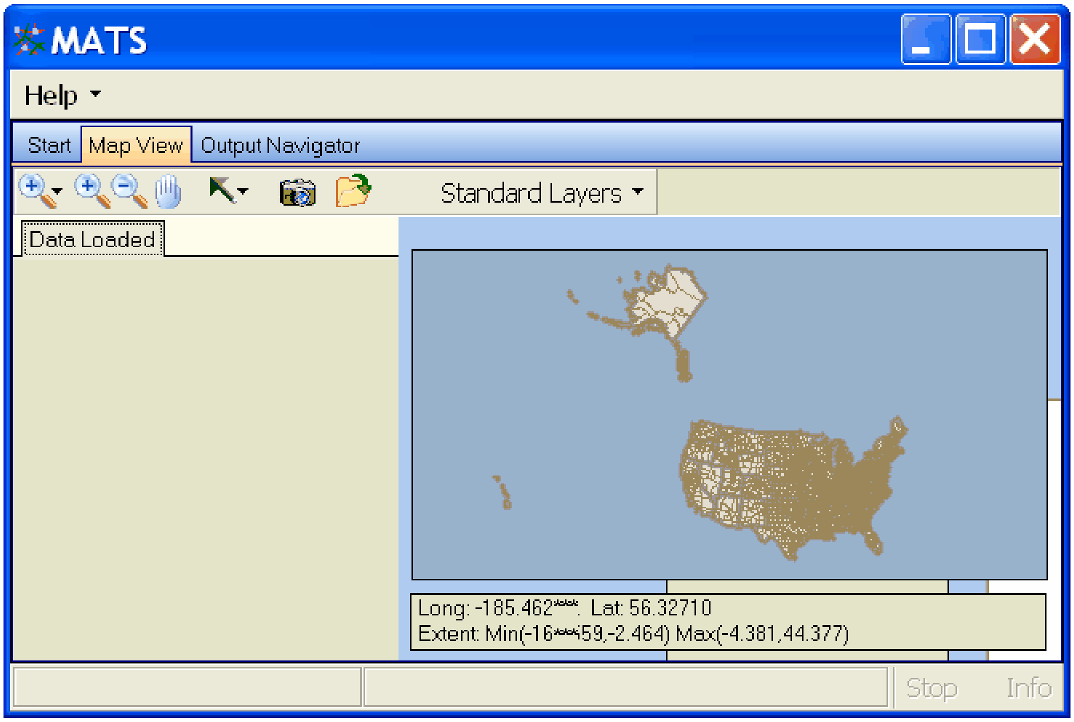



This will bring up the **Extracting. Enter output file name** window. By default, MATS will generate a folder with the Scenario Name (e.g., Example O3) and export a file with the same name used internally by MATS. You can change both the folder and the exported file name if desired.


Extracting. Enter output file name
Save in:
Example 03
My Recent Documents
Desktop
My Documents
My Computer
My Network Places
File name:
Example 03 - Spatial Field – interpolated monitor
Save as type:
CSV files (*.csv)
Save
Cancel

# 11 Map View

The **Map View** tab allows you to further explore your results. Initially, it is empty, with just a blank map of the United States.



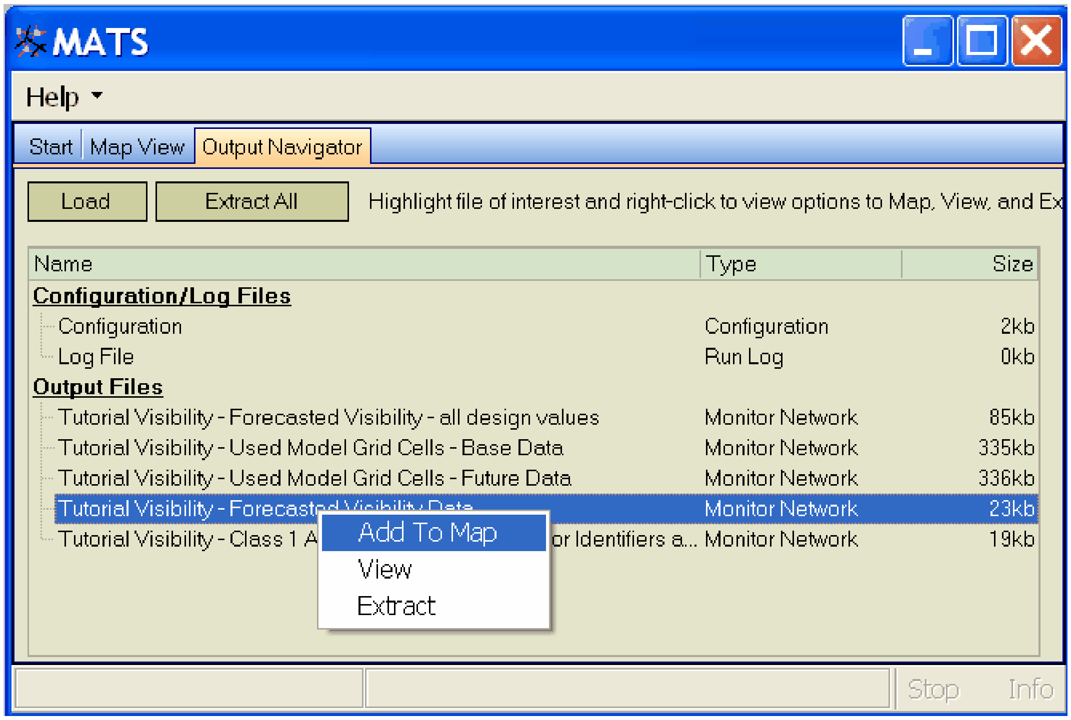

This section discusses how to:

- Load data onto the map;
- Choosing colors to represent the data (referred to as "plotting" in MATS);
- Zoom in and out on your map;
- Add and remove outlines for states, counties and Class 1 areas (these outlines are referred to as "Standard Layers");
- Exporting maps and CSV files;
- Removing data from a map.

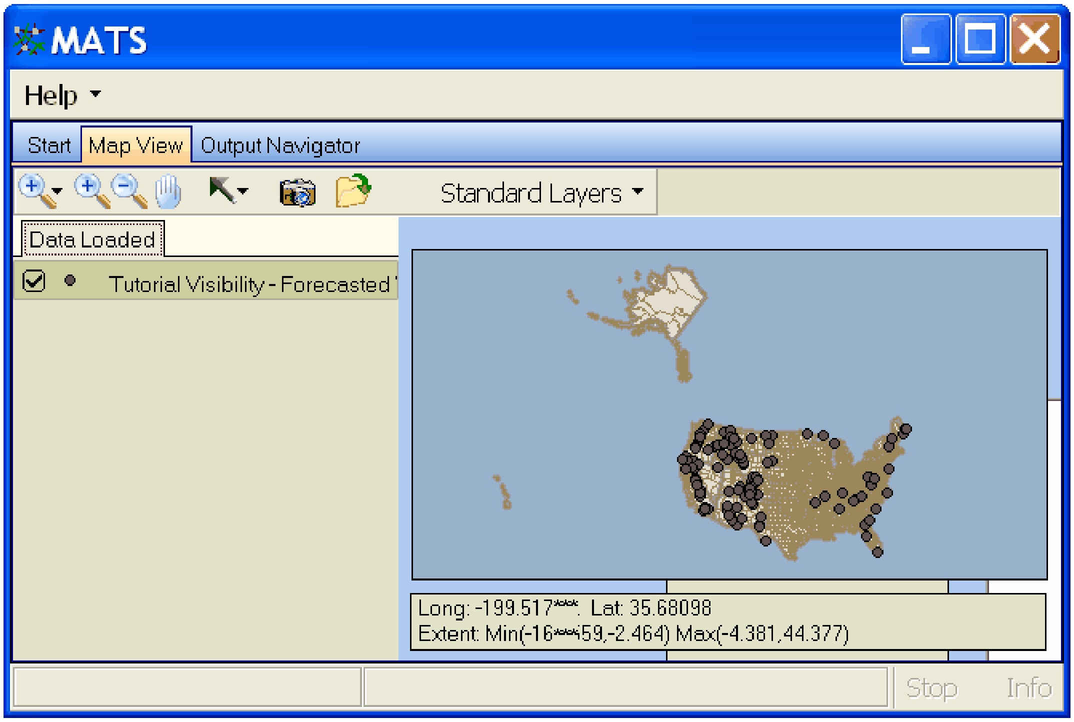
## 11.1 Loading Variables

There are two ways to bring data into a map. First, you may load data into a map with the Output Navigator. Alternatively, you can load data directly from the map view taskbar (see next sub-section).

To map your results, click on the **Output Navigator** tab. Load the ASR file that you want to view and then right-click on the particular Output File that you want to map. Choose the *Add to Map* option.



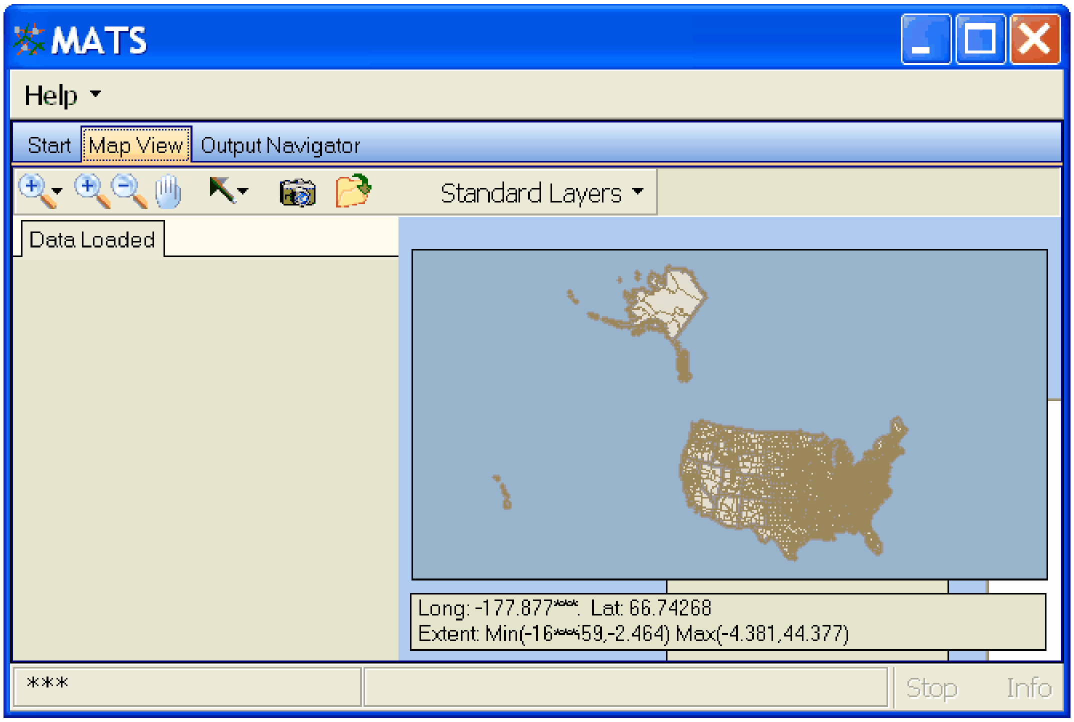

This will bring you back to the **Map View** tab.




Usually the next step is to plot your data.  This is discussed next.

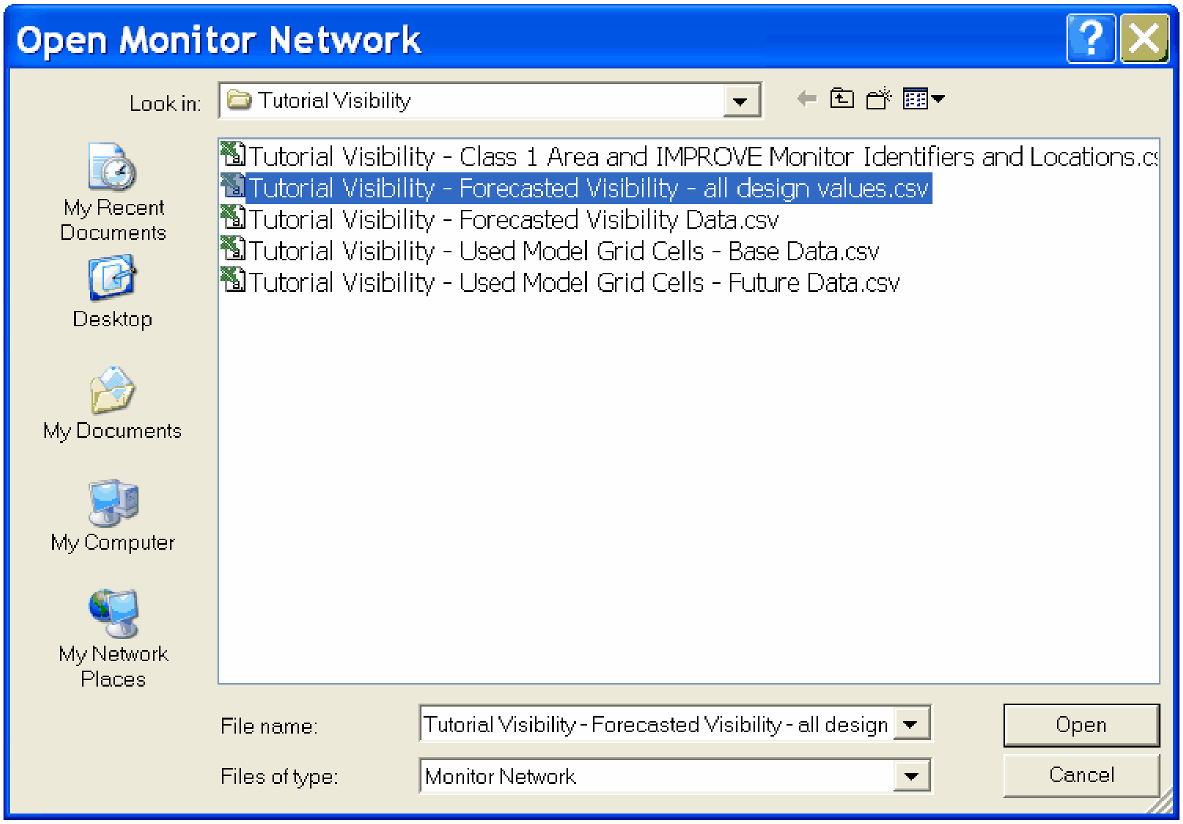
### 11.1.1 Loading with Taskbar

You can load data for mapping directly from the **MapView** tab, once you have exported your results file (as discussed in the Extract Files sub-section of the Output Navigator section).  To start, click on the **MapView** tab.

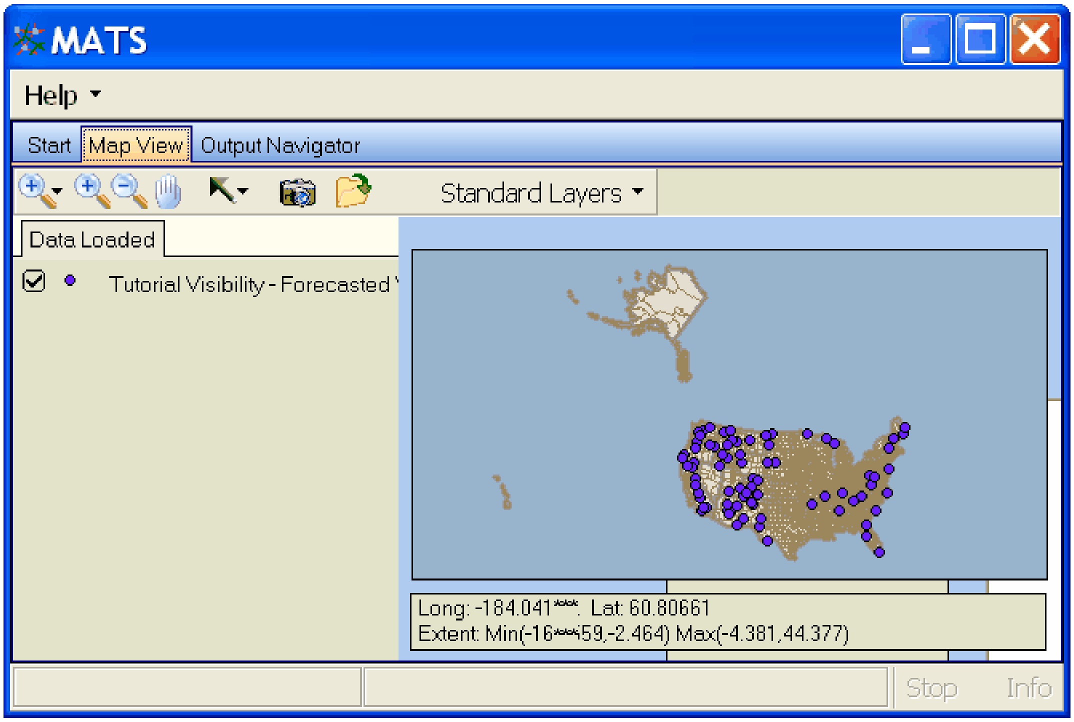



Click on the **Open a monitor network file** button: 

This will bring you to the **Open Monitor Network** window. Browse to the folder with the data file that you want to load.

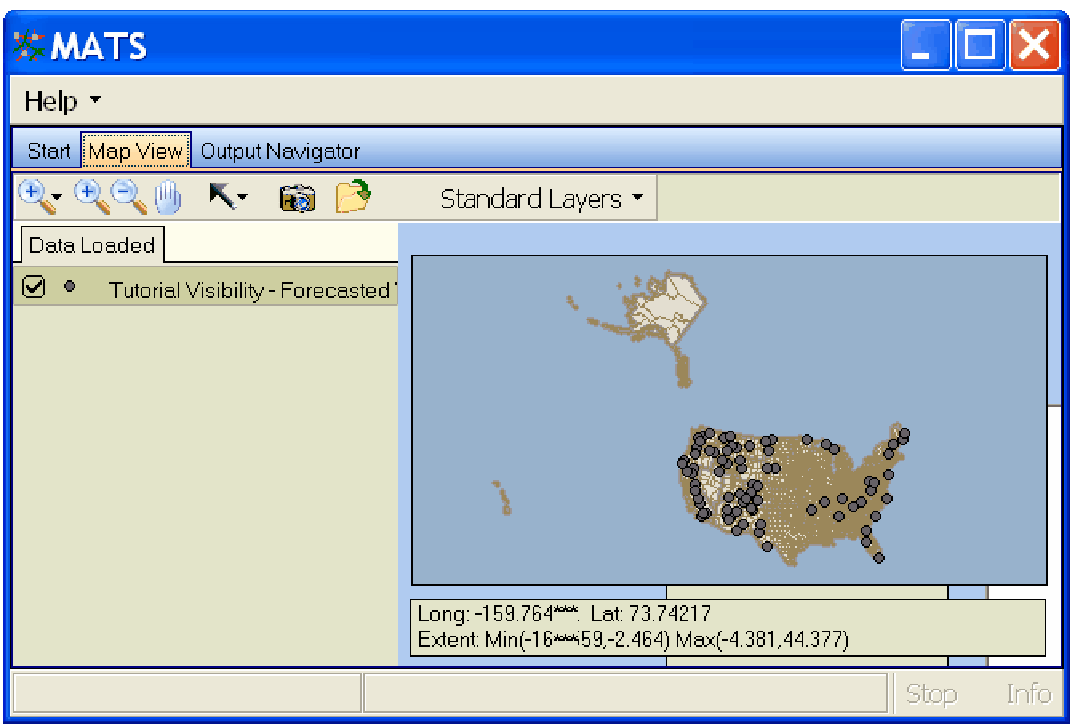



Click the **Open** button after selecting your file (or just double-click on the file you want to load) and this will take you to back to the **Map View** tab.

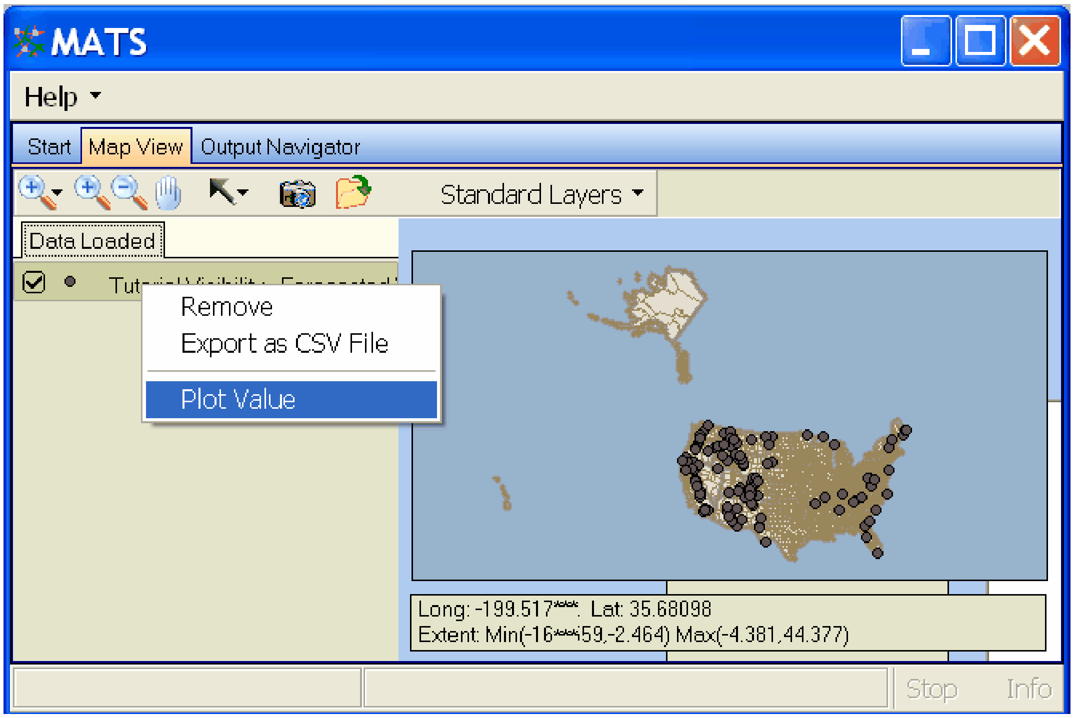



## 11.2 Plotting a Value

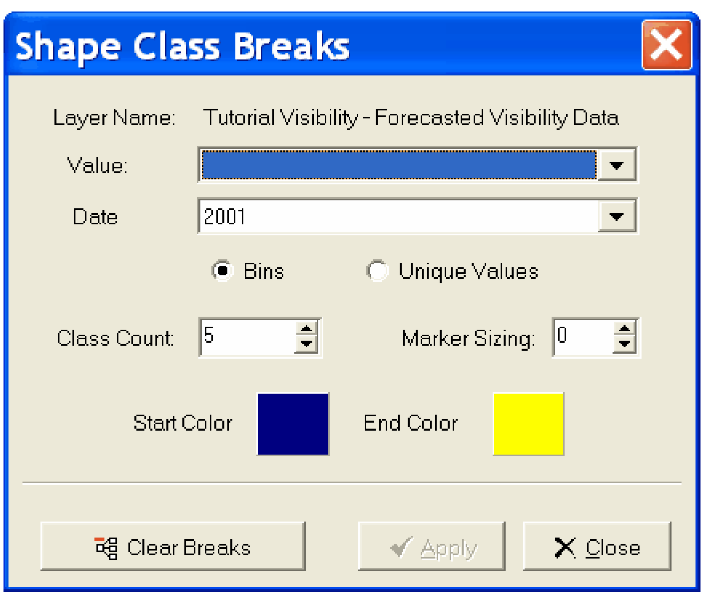
To plot a value you must first load one or more variables into the MapView.



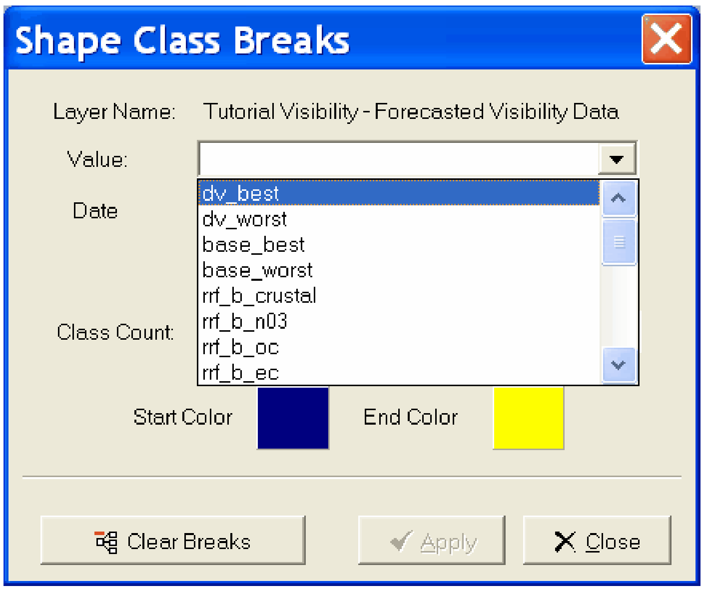
Right click on the text in the left panel and choose *Plot Value*.




This will bring up the **Shape Class Breaks** window.



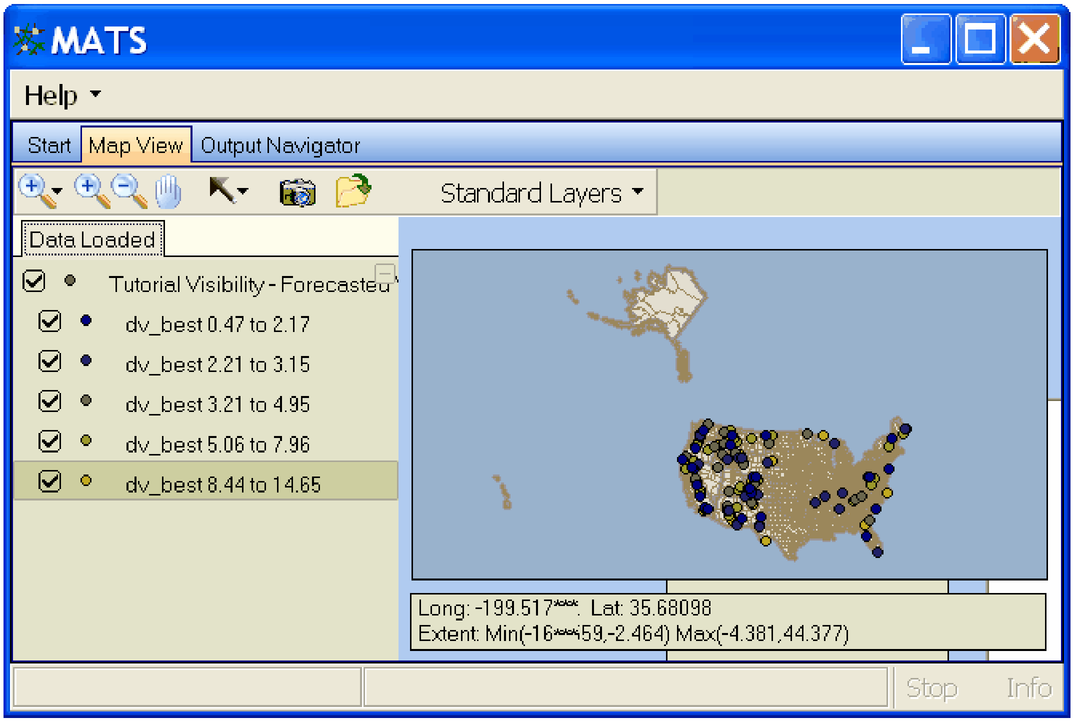
Here you can choose the variable (or "Value") that you want to display and how it will be seen. Scroll through the drop-down **Value** menu and choose *dv_best*. This is forecasted visibility (measured in deciviews) on the days with the best visibility. (Note that a description of all results variables generated by MATS are in separate "Output Variable Description" sections for PM, Ozone, and Visibility.)




There are a variety of display options that you can choose. These options are discussed in detail in the Plotting Options section. After choosing your display options, then click the **Apply** button. View the map in the **Map View** tab. (You can move the **Shape Class Breaks** window, if it is obscuring the map.)

If you want to change your display options, go back to the **Shape Class Breaks** window, make the changes, and click Apply again. You may do this as many times as needed.

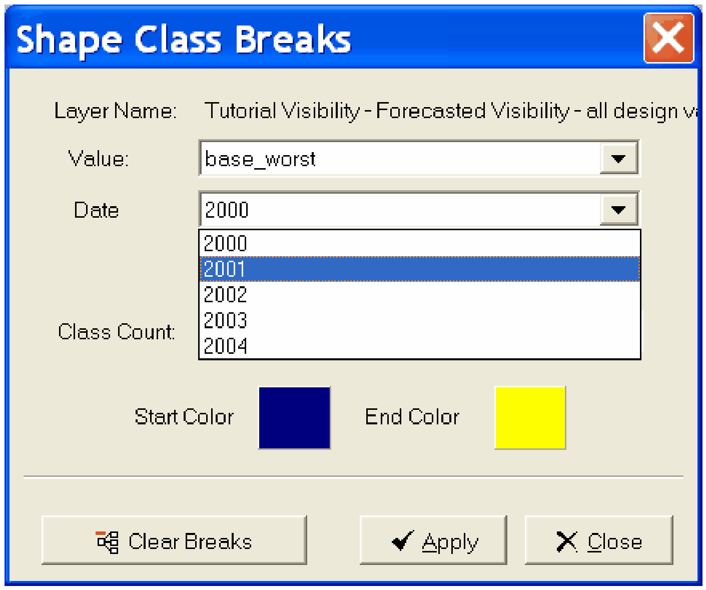
When you are satisfied with the map, click the **Close** button in the **Shape Class Breaks** window. This will bring you back to the **Map View** tab.



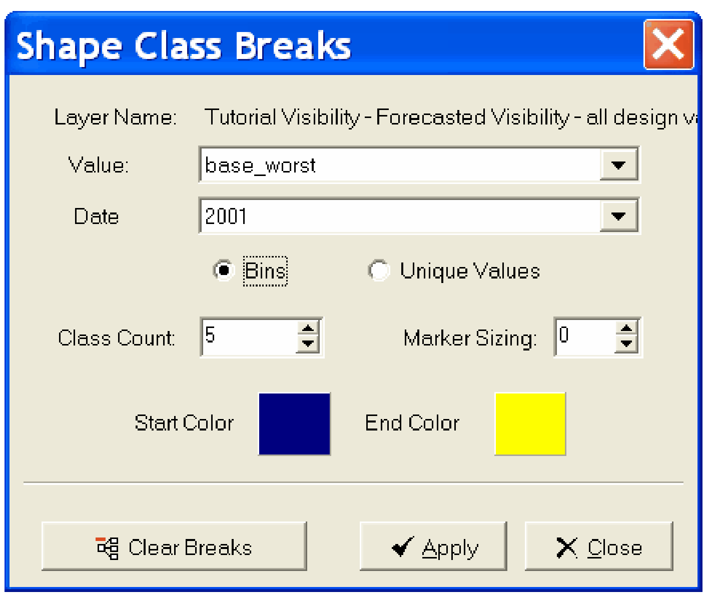

## 11.2.1 Plotting Options

MATS gives you a number of plotting options with the Shape Class Breaks window. These are demonstrated with the results file "Tutorial Visibility - Forecasted Visibility - all design values.csv" generated after completing the visibility tutorial. The same concepts hold for other results files.

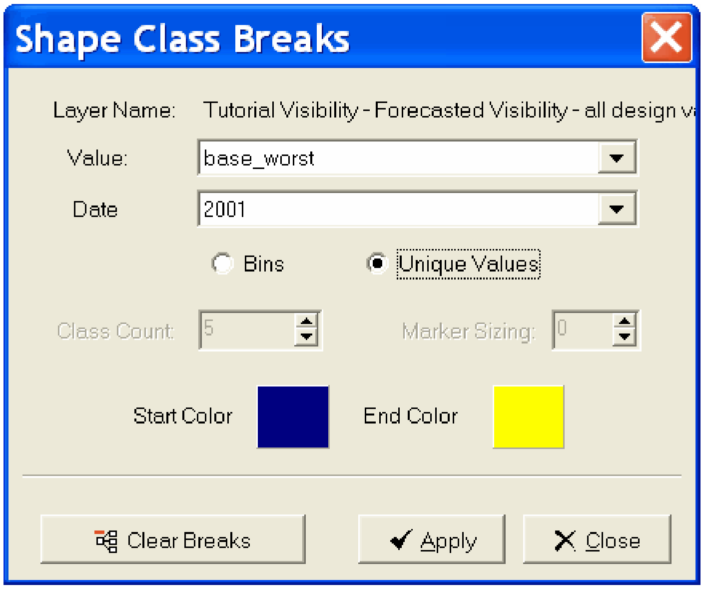
With the Date drop-down menu you can specify a particular year (assuming the data have multiple years).



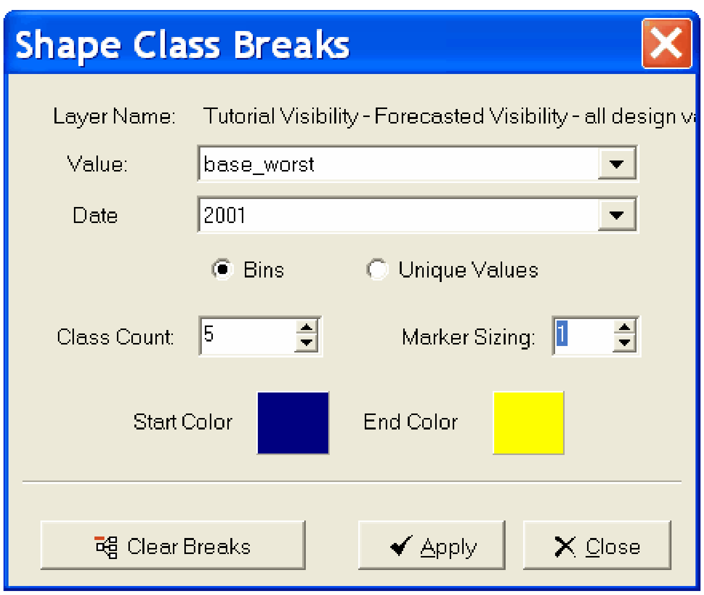

With the **Class Count** option, you can specify into how many groups you want to divide your data. The default is to use 5 bins. For most purposes this is a reasonable number.




If you choose **Unique Values** option, you will have a separate bin or group for each unique value in your data. This can lead to hundreds of bins. Generally, this is not an option that you would want to choose. Note that if you choose this option, the **Class Count** and **Marker Sizing** (discussed next) will be inoperative.

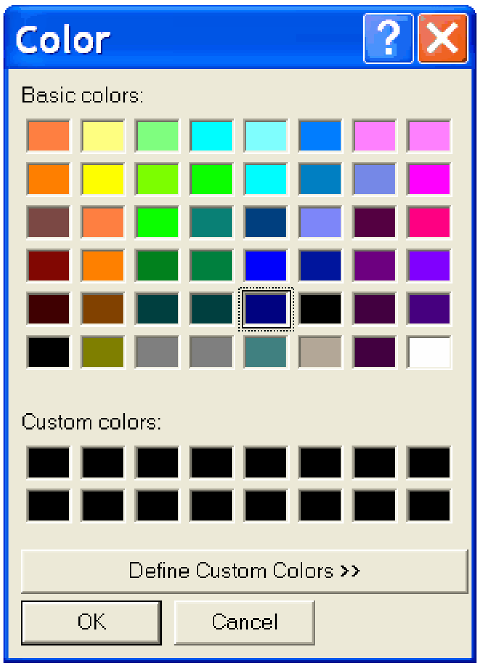



The **Marker Sizing** allows you to vary the size of the marker on your map based on the data values. The default is a **Marker Sizing** value of "0", which keeps the marker on your map all the same size. A value of "1" and higher gives the larger values progressively larger markers on the map.

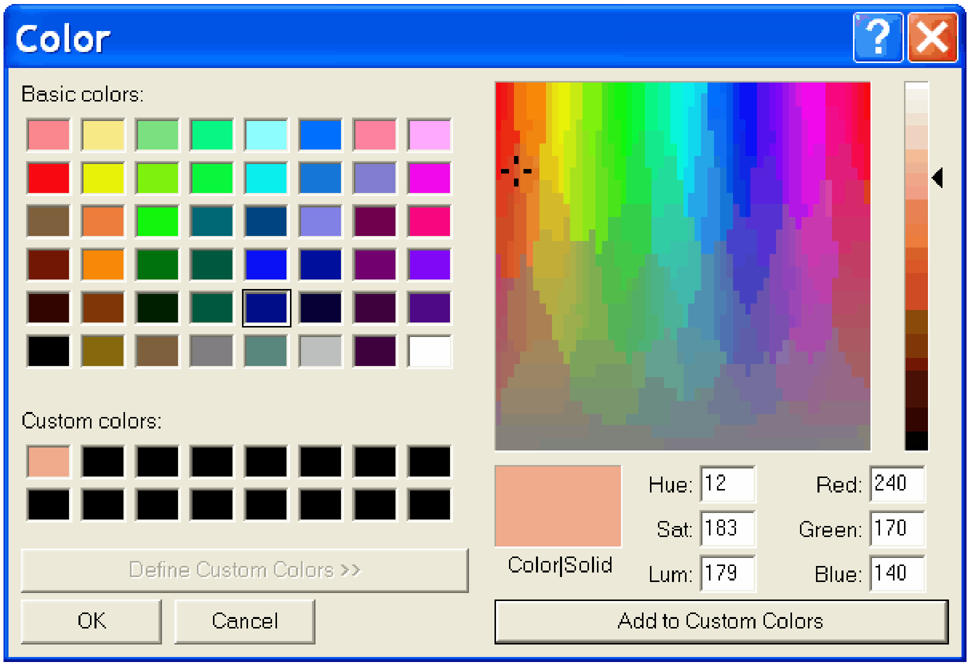



The **Start Color** option allows you to set the color of the markers for the lowest values. The **End Color** option allows you to set the color of the markers for the highest values. MATS uses a mix of these two colors for intermediate values. The default colors are blue and yellow for the start and end.

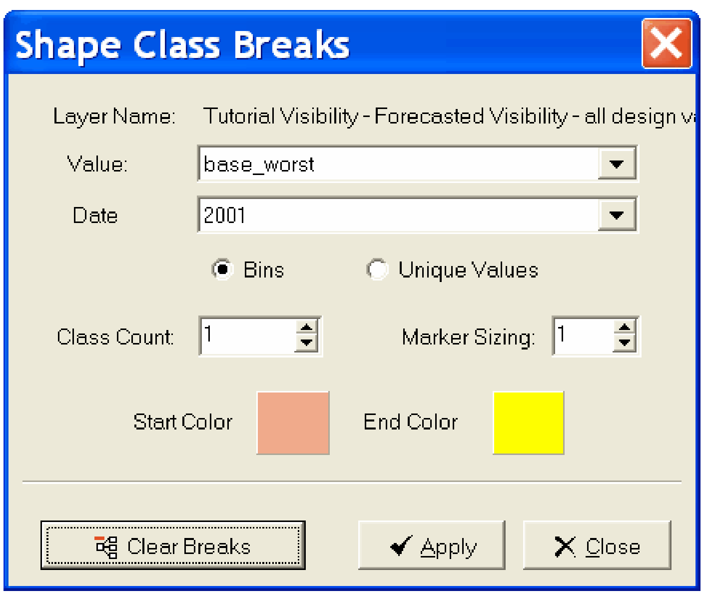
If you want to change the **Start Color**, click on the blue square.  This will bring up the **Color** window.  The simplest option is to click on the color you prefer from the pre-defined **Basic colors** panel (in the upper half of the **Color** window), and then click **OK**. (You can  also double-click on desired color.)




If for some reason, you do not see the color you want to use in the **Basic colors** panel, you can click the **Define Custom Colors** button.  Click in the large multi-color square to identify the color you want and then adjust the hue with the slider bar on the far right.  You can save the color you generate by clicking the **Add to Custom Colors** button.




When satisfied, click **OK**. This will bring you back to the **Shape Class Breaks** window.



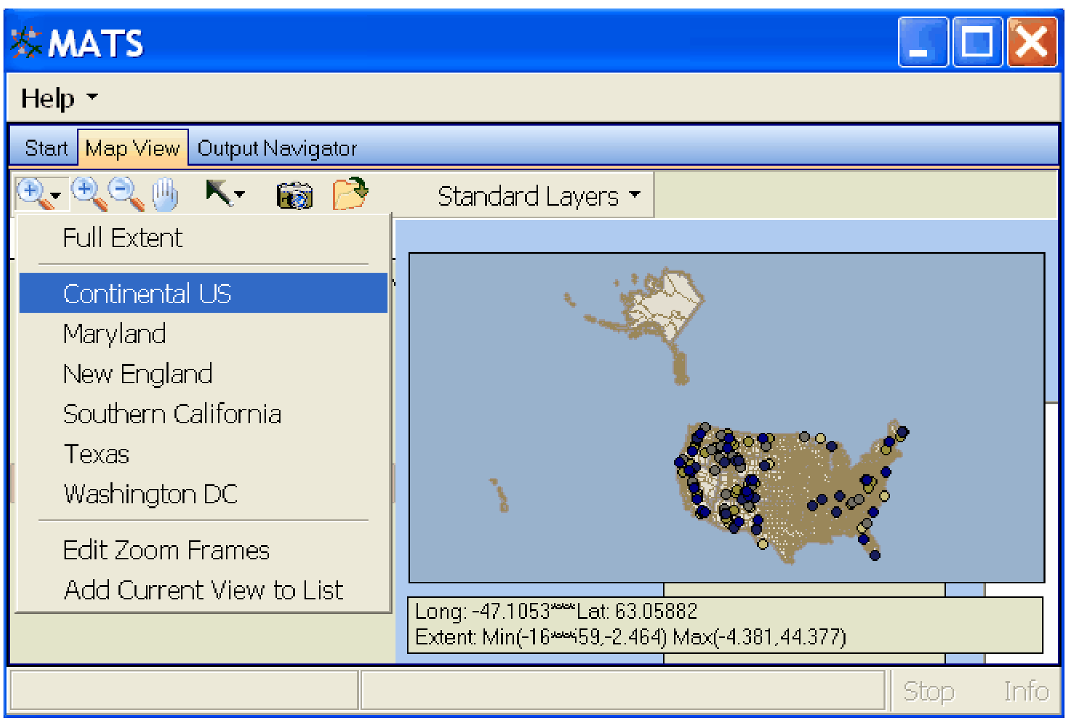

You can change the End Color through a similar process.

To test how your colors look, click the **Apply** button. If you do not like what you see, click the **Clear Breaks** button. When you are finally satisfied with the look of your map, click the **Close** button.

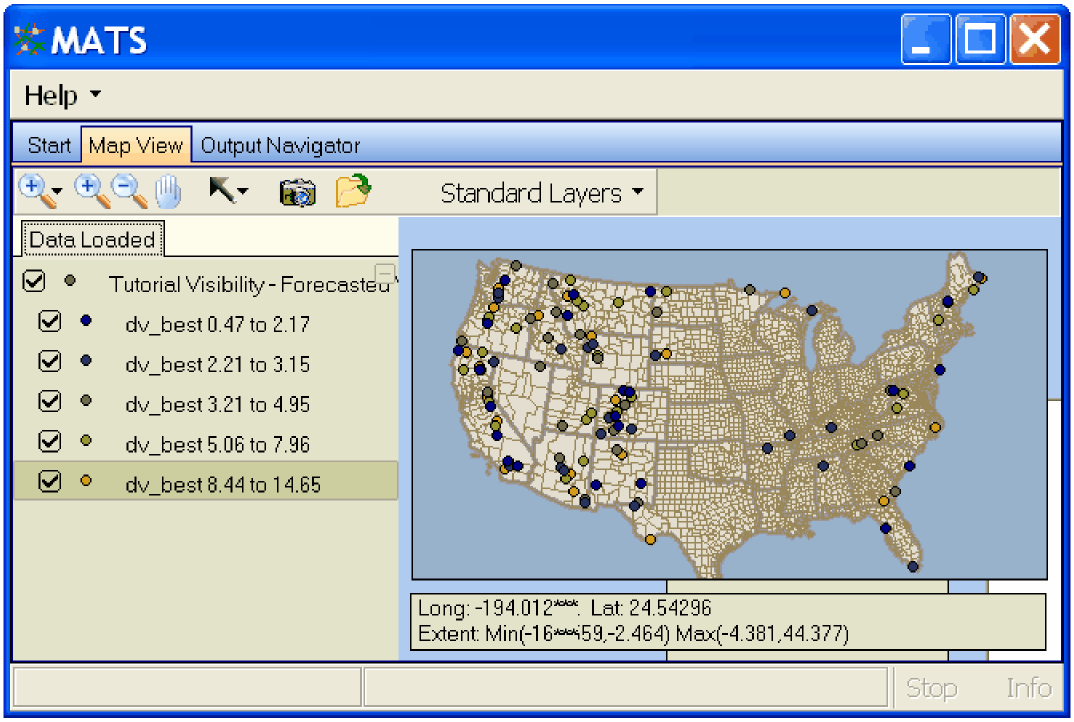
## 11.3 Zoom Options & Pan View

In addition to the plotting options available in the Shape Class Breaks window, there are various options on the task bar that you can choose to adjust the map. There are standard Zoom in and Zoom out options, as well as a Pan option that lets you manually move the map.

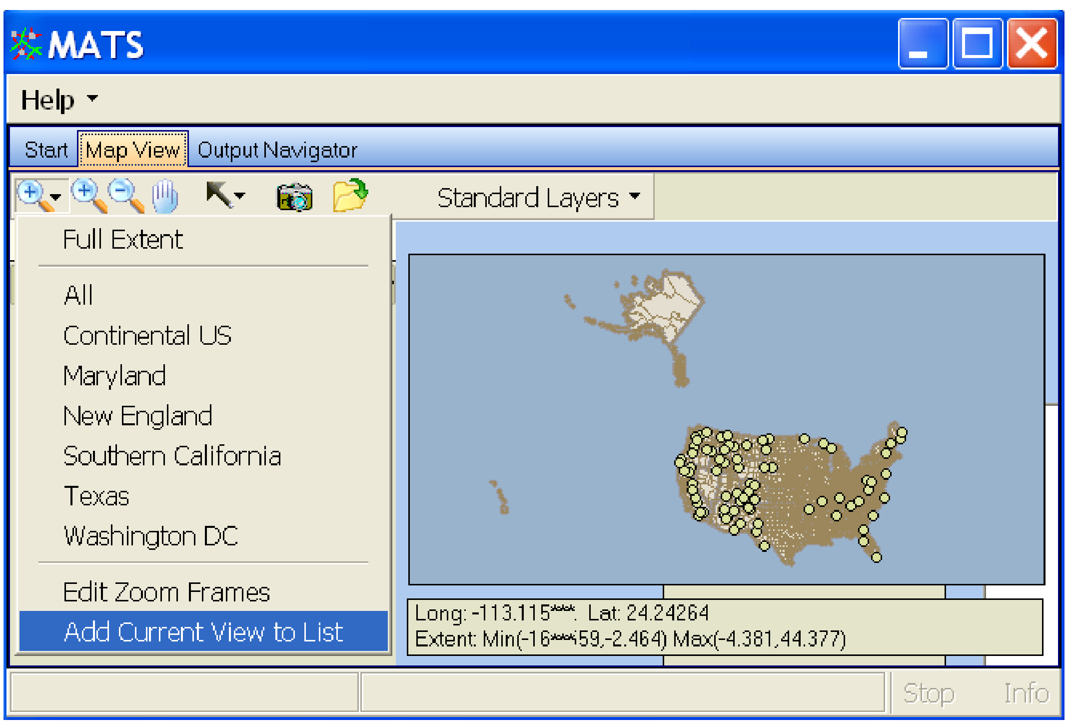
In addition, there is a **Zoom to an area** drop-down menu . This lets you zoom to pre-specified regions, or "zoom frames", such as the continental US.



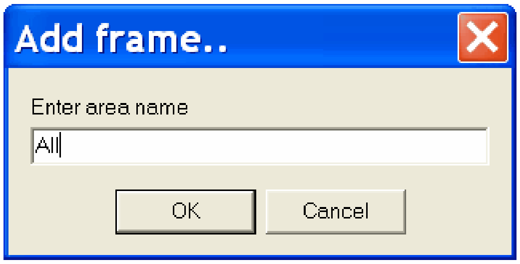

Choosing the *Continental US* zooms in so that you just see the continental US.




If desired, you can change the "Zoom Frames" to whatever you are currently viewing. Choose *Add Current View to List* from the list of options in the drop-down menu.



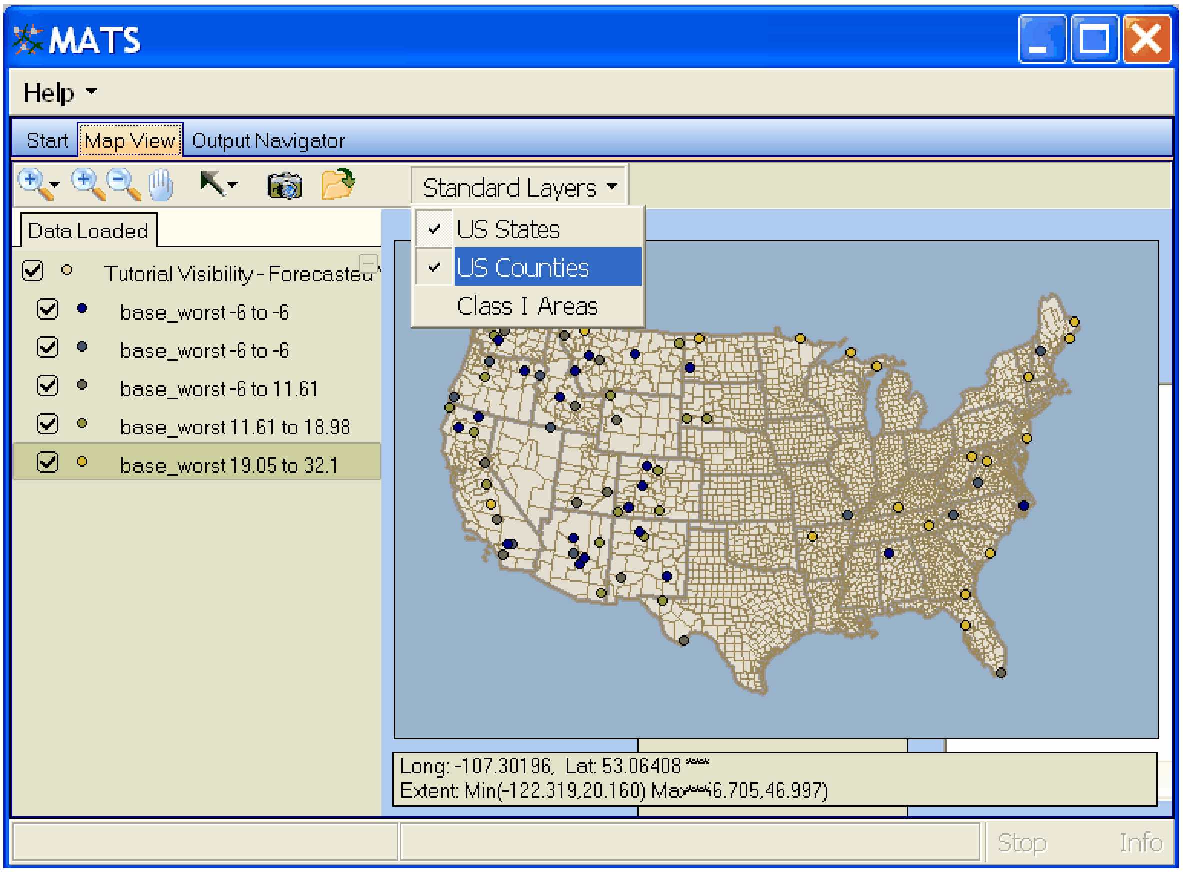
This will bring up the **Add Frame** window. Type in whatever name you want to use for this "zoom frame" and this will be available whenever you use MATS.



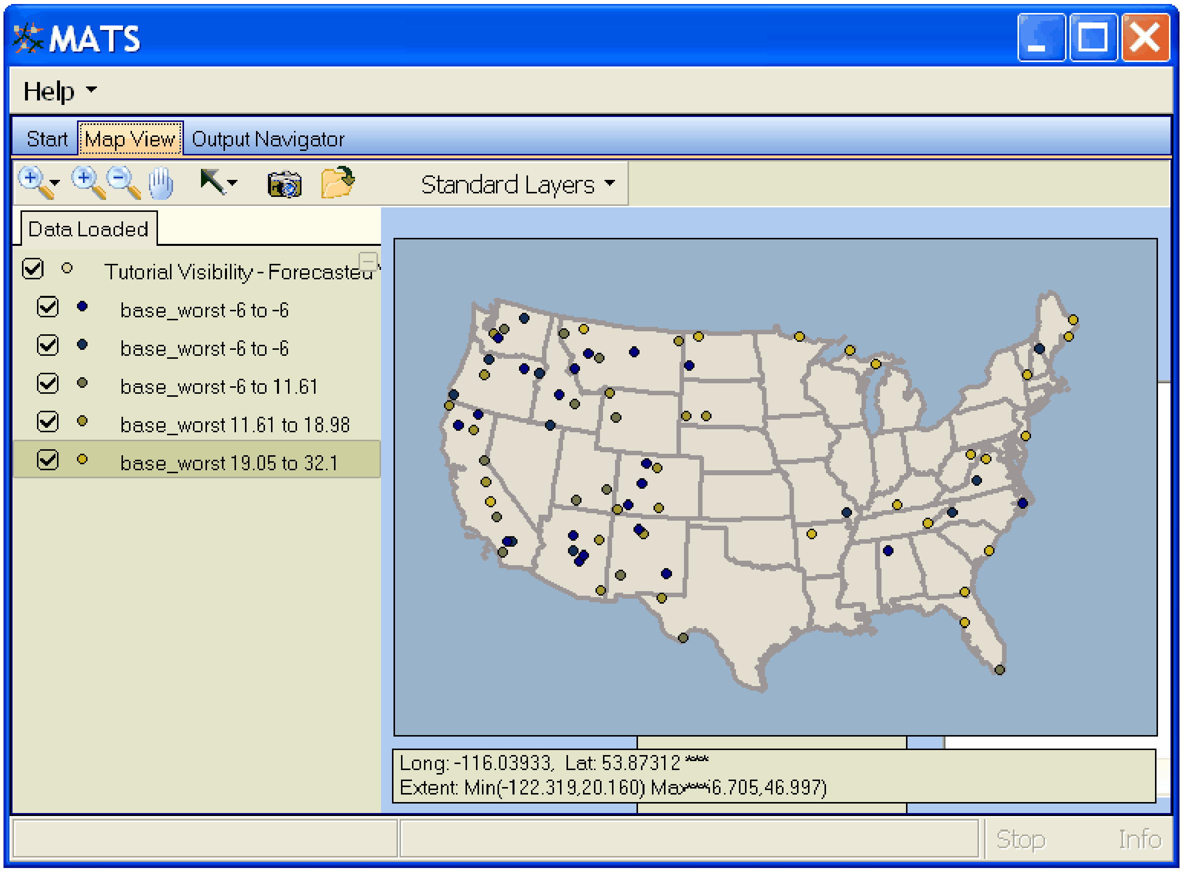

## 11.4 Standard Layers

The **Standard Layers** drop-down menu allows you to add and remove state, county, and Class 1 area borders. By default, MATS displays the state and county borders. These can often provide useful context to maps, however, at times they can obscure the markers somewhat -- this is most often a problem with the county boundaries.

To eliminate a layer, open the **Standard Layers** drop-down menu and click on the active layer that you want to remove.



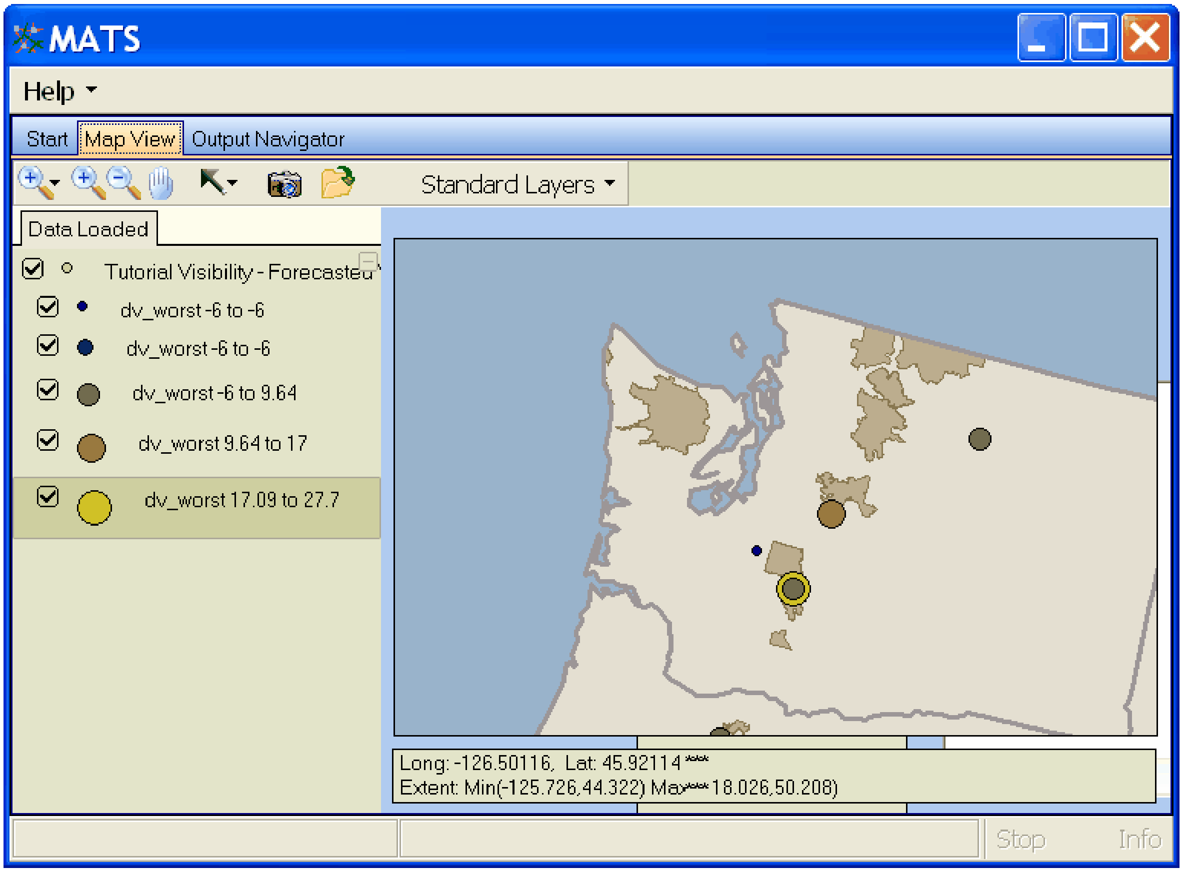

This will bring up a map view with the layer removed.



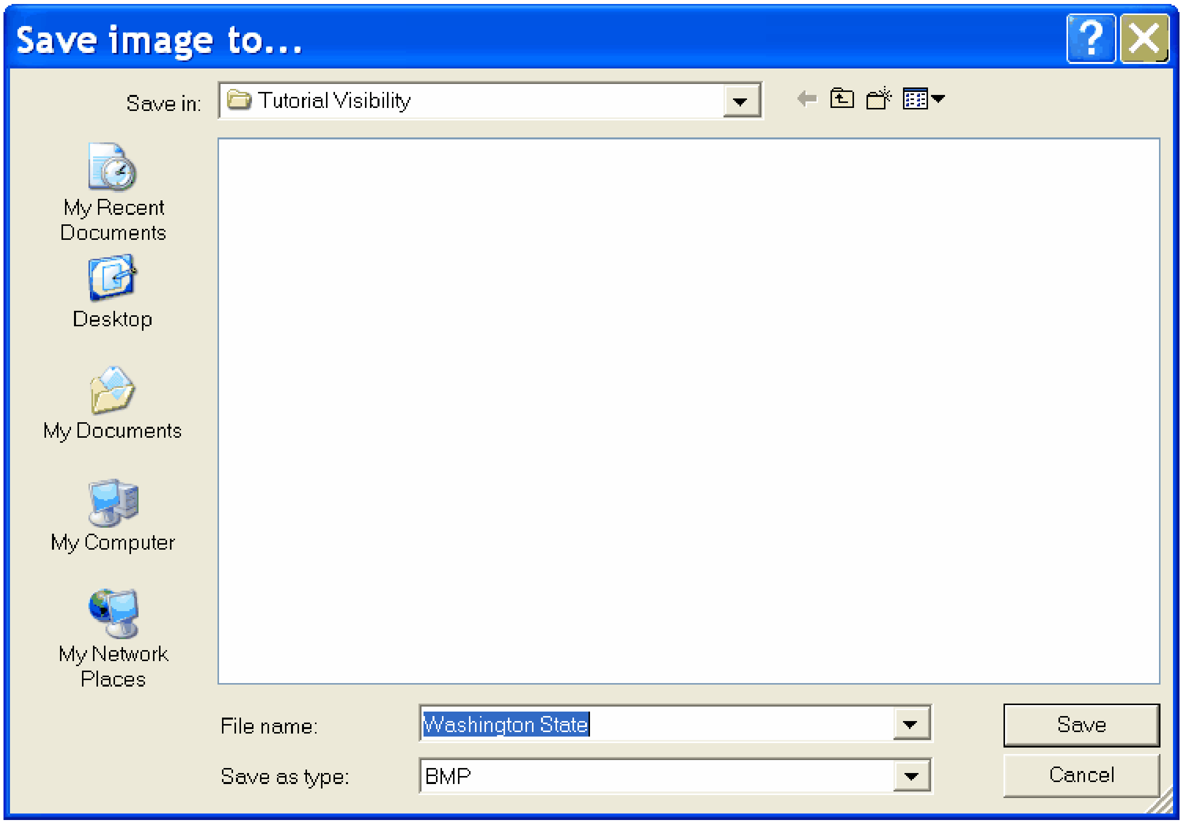

To add a layer back, choose the layer you want to add from the **Standard Layers** drop-down menu.

## 11.5 Exporting Maps & Data Files

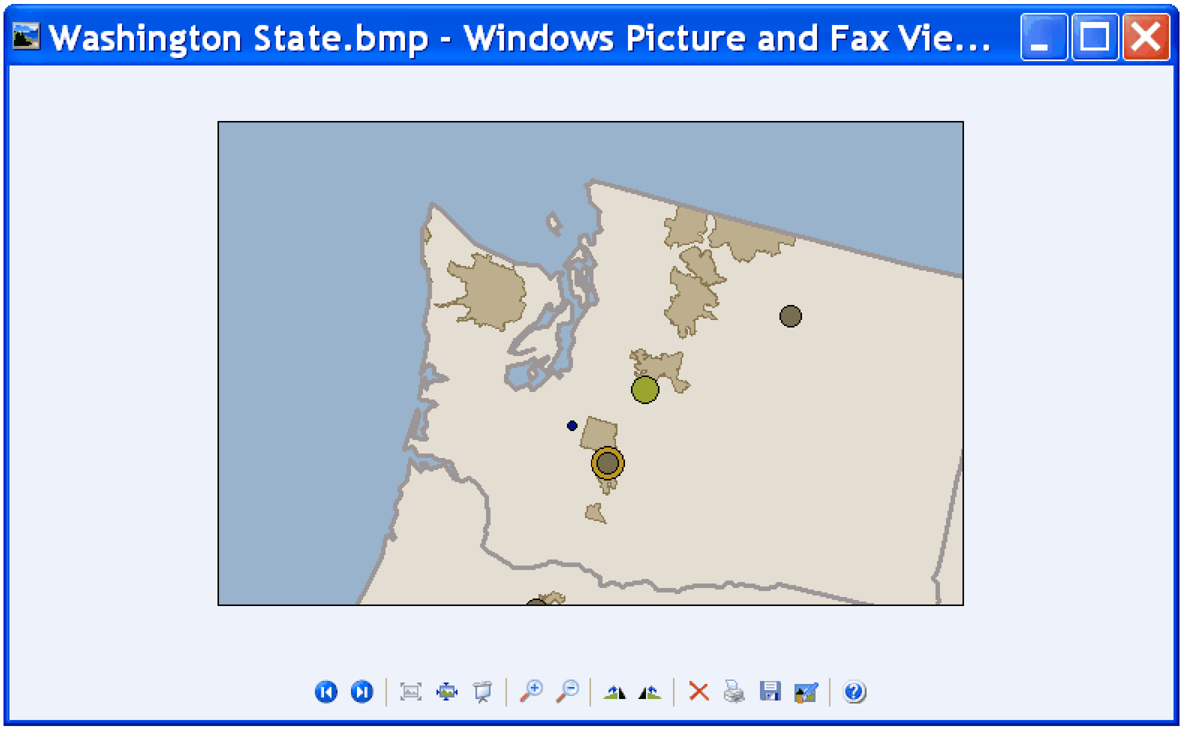
MATS allows you to export maps and data from the **Map View** tab. To export a BMP file, click on the **Export current map view to an image file** option . (The next sub-section discusses exporting the underlying data.)




This will up a window where you can name your image. Browse to whatever folder in which you want to store your image.

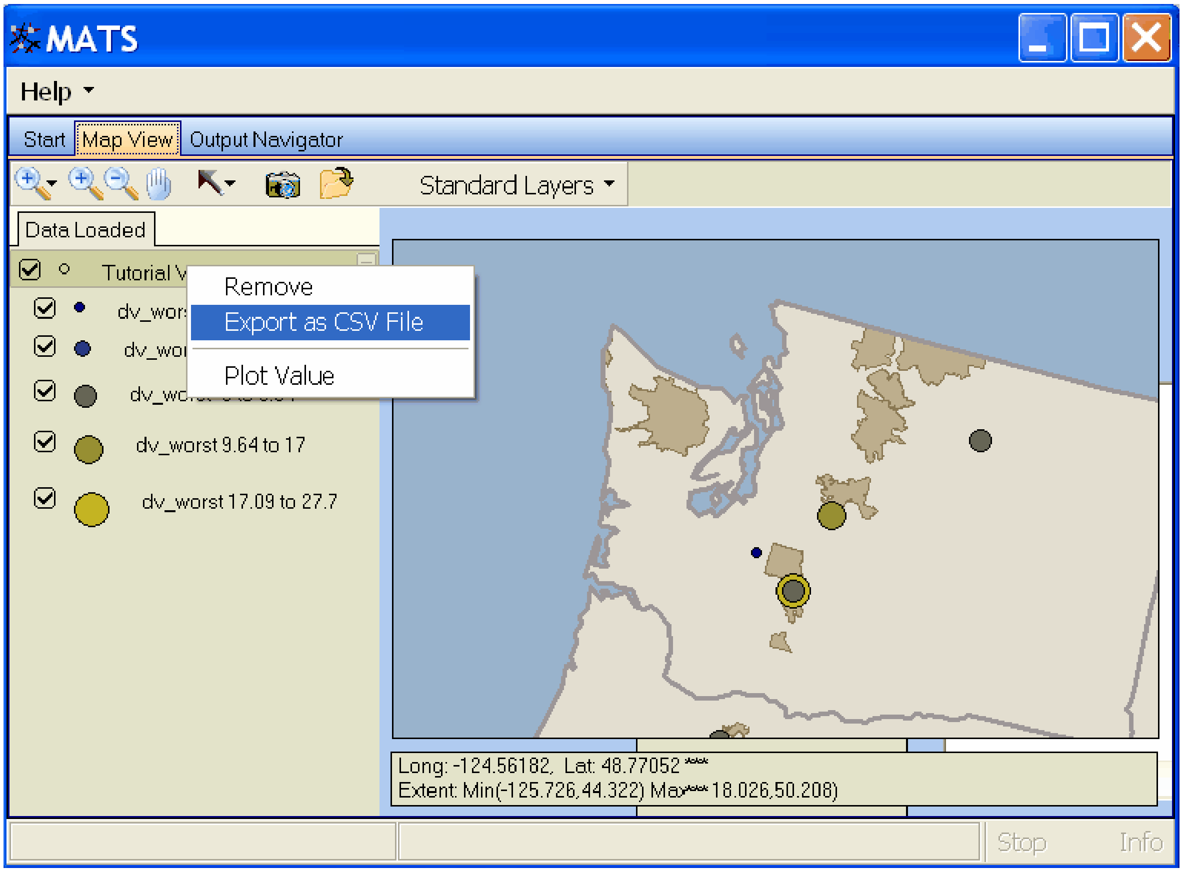



Your .BMP file can be easily viewed in a variety of software applications. Note however, that this is just an image, and you will not be able to work with it in a GIS program the way you might work with a .SHP file.




### 11.5.1 Exporting CSV Data File

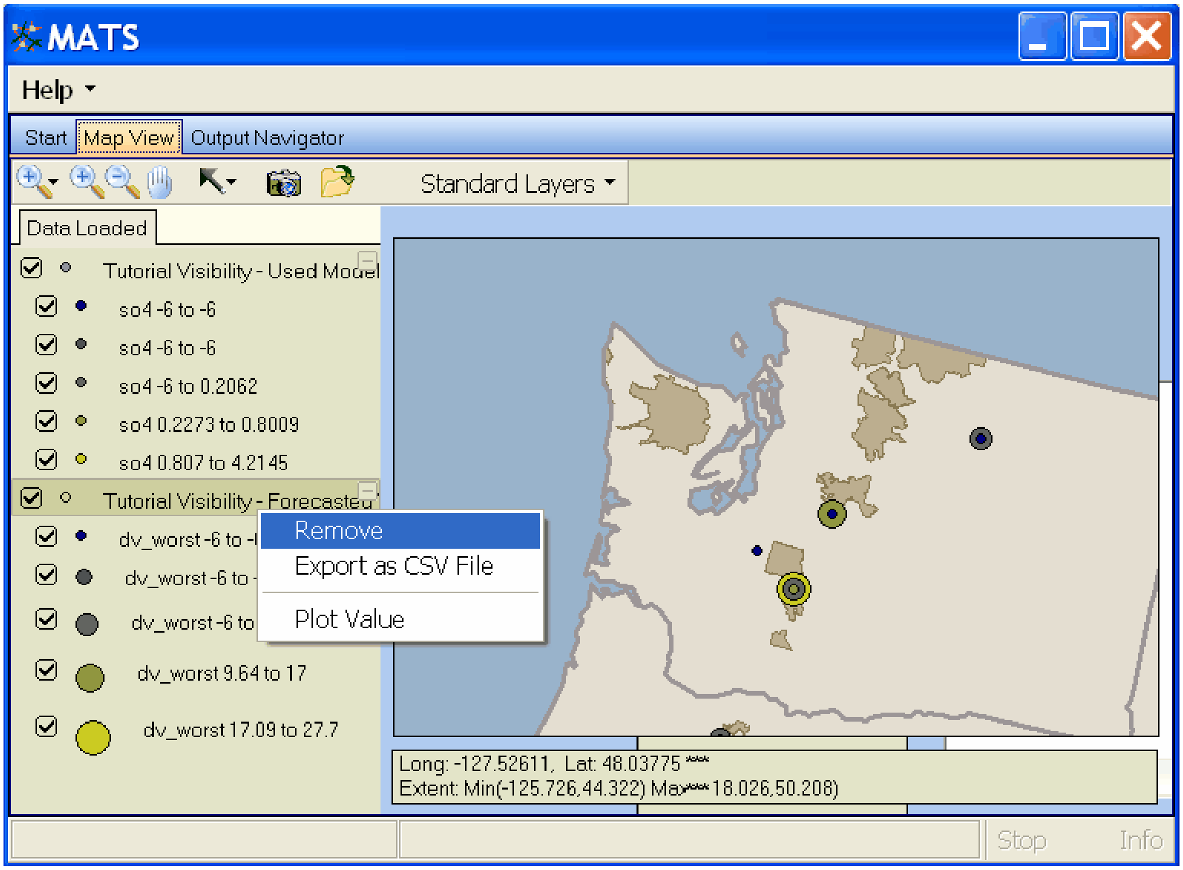
If desired, you can export a CSV file with the data used to generate your map. Just right click on variable of interest in the left panel, and choose the *Export as CSV File* option.



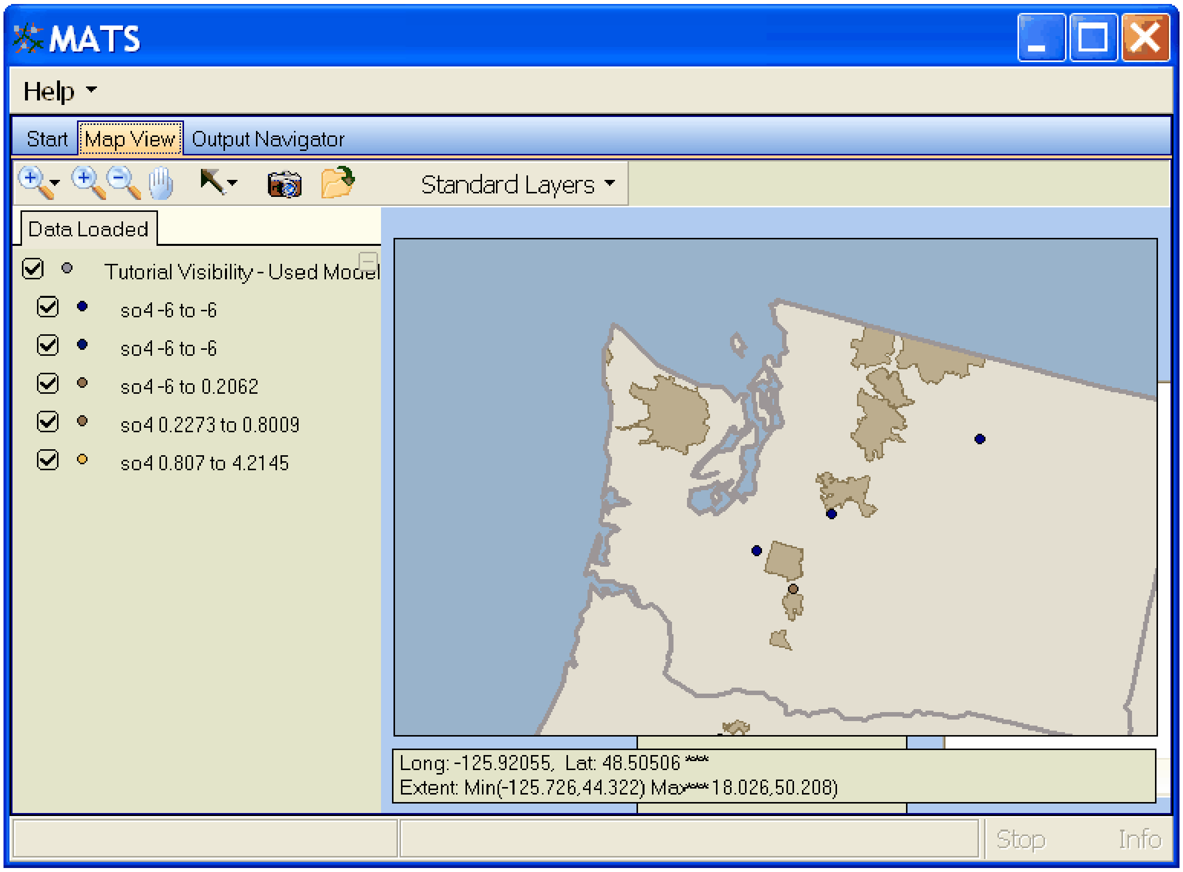

Note that this exports the same data that the [Output Navigator] would export. Choose whichever approach is easier.

## 11.6 Removing Data

You can have multiple data files in a map. If you decide to remove a datafile, right click on the variable that you want choose the *Remove* option.




This will bring back the map without the undesired data.


MATS
Help
Start
Map View
Output Navigator
Standard Layers
Data Loaded
Tutorial Visibility - Used Model
so4 -6 to -6
so4 -6 to -6
so4 -6 to 0.2062
so4 0.2273 to 0.8009
so4 0.807 to 4.2145
Long: -125.92055, Lat: 48.50506
Extent: Min(-125.726,44.322)
Stop
Info

# 12 Frequently Asked Questions

This section answers questions that have arisen when running MATS.

## 12.1 Error: MATS will not create a folder for extracting files

If an output folder already exists MATS will return an error if you click the Extract All button. This occurs even if the pre-existing folder is empty.


This error can be avoided by using a different folder name or removing the pre-existing folder.

## 12.2 Where is there a description of output variables?

Descriptions of the output variables are in the separate "Details" sections for PM, Ozone, and Visibility.

## 12.3 Why no PM analysis?

This feature is under development.

# 13 References


Frank, Neil, (2006): "Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities" JAWMA. Vol 56: 500-511.

IMPROVE, (2006), "Revised IMPROVE Algorithm for Estimating Light Extinction from Particle Speciation Data", January 2006, http://vista.cira.colostate.edu/improve/Publications/GrayLit/gray_literature.htm

U.S. EPA (2006), "Procedures for Estimating Future PM2.5 Values for the PM NAAQS Final Rule by Application of the Speciated Modeled Attainment Test (SMAT)" http://www.epa.gov/scram001/guidance_sip.htm.

U.S. EPA (2007), "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze", April 2007. EPA-454/B-07-002, http://www.epa.gov/scram001/guidance_sip.htm.